GETTING OUR ACT TOGETHER: AN EXPLORATION OF THE MECHANISMS RESPONSIBLE FOR THE AFFILIATIVE CHANGES EVOKED BY INTERPERSONAL MOVEMENT

by

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ABSTRACT

This thesis explores the reasons why dyads whose movements are aligned (i.e., synchronous) report greater levels of affiliation than those whose movements are not (i.e., asynchronous). Though previous research has suggested that outcomes are influenced by self-other overlap, via action co-representation and/or self-other similarity, none has examined this directly, or considered the effects of participants' judgements about their co-actor's relative performance. Previous research has also neglected the fact that dyadic movement can be aligned or misaligned in a variety of ways (e.g., topologically in terms of what movements are made and temporally in terms of when the movements are made), providing little evidence for the mechanisms supporting the alignment-affiliation relationship. Across three experiments, dyads (N=534; 267 dyads) were randomly assigned to perform arm movements that were aligned or misaligned temporally or topologically. Control participants made matching arm movements while facing away from their co-actor, removing visual alignment cues and controlling for the effects of movement. Action co-representation, self-other similarity, and interaction judgments about alignment with the co-actor were tested. Evidence was found favouring the role of meta-judgments, while alignment, but not misalignment, affected affiliation. These findings suggest that high order judgments, and not self-other merging, may be responsible.

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CHAPTER 1: A FRAMEWORK FOR INVESTIGATING INTERPERSONAL MOVEMENT ALIGNMENT AND AFFILIATION

This chapter introduces prosocial interpersonal movements—movements that are conducted in the presence of another person and that are understood to increase affiliation. A novel taxonomy based on the dimension of alignment is used to differentiate different types of interpersonal movement, and to identify the challenges of understanding the mechanisms responsible for their effects. This taxonomy is also used to highlight an interpersonal movement type with under-researched affiliative outcomes (paired action). The chapter ends with an overview of the experiments reported in the thesis, and a brief description of the mechanisms that each sought to test.

1. Introduction

Aligned interpersonal movement has many affiliative effects. Behavioural synchrony—moving together through time and space—is associated with greater liking (Hove & Risen, 2009; Tarr, Launay, Cohen, & Dunbar, 2015), rapport (Bernieri, 1988; Bernieri, Davis, Rosenthal, & Knee, 1994; Cappella, 1997; Miles, Griffiths, Richardson, & Macrae, 2010; Miles, Nind, & Macrae 2009; Tickle-Degnen & Rosenthal, 1990), connectedness and trust (Bernieri et al., 1994), and likelihood of and propensity for cooperation (Cross, Wilson, & Golonka, 2016; Wiltermuth & Heath, 2009; Wiltermuth, 2012), relative to asynchronous movement. Behavioural mimicry—copying another's movement—is also associated with greater rapport

(Lakin & Chartrand, 2003), liking (Chartrand & Bargh, 1999), connectedness (Ashton-James, van Baaren, Chartrand, Decety, & Karremans, 2007), as well as helping behaviour (van Baaren, Holland, Kawakami, & Van Knippenberg, 2004), relative to an absence of mimicry. However, the mechanisms by which aligned movement promote affiliative outcomes remain underspecified.

1.1 Interpersonal Alignment and Affiliation

Evidence for the effect of interpersonal alignment on affiliative outcomes is relatively recent, but robust. In terms of synchrony, for example, Hove and Risen (2009) found that participants reported an experimenter as more likeable to the extent that they tapped in time with them (Experiment 1) and that synchrony itself was responsible for this increased level of likeability (Experiment 2). In Experiment 2, participants tapped in time with a moving visual target—a vertically oscillating bar—that moved at either a fast (520 ms) or a slow (600 ms) tempo. Seated to one side of the participant, an experimenter tapped in time with a separate visual stimulus, which was set to oscillate at the same or a different tempo, or rested her hands on her lap. As a result, each participant tapped synchronously or asynchronously together, or tapped alone (baseline). Synchronous tapping brought about more positive self-reported levels of affiliation than either asynchrony or baseline, for which affiliation ratings did not differ. Hence temporal alignment during topologically matched movements (synchrony) increased affiliation while temporal mismatch during the same (asynchrony) had no effect.

Using a similar paradigm, Valdesolo and DeSteno (2011) showed that participants who tapped synchronously or asynchronously with a confederate were differentially likely to feel compassion for and help the confederate. After a tapping task in which they synchronised their tapping to the same or different audio clips, participants rated, among other things, their liking for their co-actor and the degree to which they felt that they had a similar personality to her. Participants were then required to view the on-screen decisions of another confederate at a separate computer terminal, ostensibly as part of a pre-test for a novel experimental procedure. The decisions they observed showed this second confederate assigning themselves an easy, 10-minute task, and a relatively arduous 45-minute task to the previous confederate from the tapping task, consisting in part of a series of puzzles. Participants not only reported more liking for and perceived similarity to the tapping confederate when their tapping was synchronous rather than asynchronous, but were also more likely to secretly help her to complete the puzzles that she had been assigned unfairly. Path analysis revealed that the level of perceived similarity mediated both participants' decision to help this co-actor and the amount of time that they subsequently spent doing so. Synchrony therefore influences liking and, by increasing the perceived similarity of co-actors, seems to account for increased levels of compassion and helping behaviour.

Research into the effects of mimicry—the automatic imitation of posture, gestures, and actions (for a review, see Chartrand & Van Baaren, 2009)—has also pointed to positive affiliative outcomes. Chartrand and Bargh (1999, Experiment 2), for example, showed that when confederates covertly replicated the movements of participants, they were more liked by participants; these participants also reported an increased sense of rapport with their mimicker. To test this, the researchers had participants interact with a confederate, taking turns with her to describe a series of photographs. During this time, the confederate either copied or did not copy the participant's mannerisms. When the photograph description phase of the experiment was over, participants completed a questionnaire with items assessing their liking for the confederate and how smoothly they believed the interaction had gone. Mimicked participants reported more liking for the confederate and a greater sense of rapport than controls.

As with synchrony, Van Baaren and colleagues (Van Baaren et al., 2004) have also shown that mimicry increases both liking and helping behaviour. In one of a series of experiments, the researcher subtly mimicked the participant during the supposed main task, and subsequently dropped stationery on the floor. Participants who were mimicked were more likely to help retrieve it than those who were not. Moreover the prosocial effects of being mimicked even extends to others, as mimickees are more likely to help an experimenter who was not present while they were being mimicked, and to donate greater sums of money to charity (van Baaren *et al.*, 2004). Indeed increased affiliation and prosociality are common findings in the field (for a review, see Van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009).

1.2 Dimensions of Interpersonal Alignment

As this review suggests, synchrony and mimicry appear to promote similar outcomes. In addition, synchrony and mimicry both involve movement alignment, albeit of slightly different forms. Interpersonal movement can be aligned (or misaligned) in two ways: temporally (i.e., in terms of movement phase and frequency) and topologically (i.e., in terms of involving the same body parts moving in the same direction and with the same amplitude). Synchrony and mimicry, as two forms of interpersonal movement, can both be characterised along these dimensions. Specifically, synchrony can be defined as interpersonal movement that is both temporally and topologically aligned, and mimicry can be defined as interpersonal movement that is topologically aligned but temporally misaligned. However, synchrony and mimicry differ on a number of key dimensions. As with the experimental manipulations described above, synchrony is usually elicited in experimental settings by common entrainment to a shared external cue. For example, participants may be asked to tap their index finger to a vertically oscillating bar that, in the synchronous condition, is set to oscillate at the same tempo for both the confederate and participant (e.g., Hove and Risen, 2009). In contrast, since mimicry entails the covert imitation of a participant's movements they are usually distinct in terms of their form to those used in synchrony research. Since mimicry consists of the covert replication of a participant’s actions by a confederate the target movements themselves are typically discrete (i.e., non-continuous, non-repetitive), and include a wide variety of different movement types. Hence, a mimicked participant’s postural adjustments, gestures, and actions, may all be mimicked by the confederate during during a single mimicry block (see Van Baaren et al., 2009; Chartrand & Van Baaren, 2009). In synchrony research however, the same, usually continuous movement, is undertaken by both participant and confederate throughout the synchronous block.

As Table 1 depicts, when temporal and topological alignment are considered separately, it becomes clear that synchrony and mimicry (which we refer to in the current research as *turn-taking*, a point to which we will return) are only two possible forms of interpersonal movement. The research reported in Chapters 2–4 of this thesis used this taxonomy to explore *how* interpersonal movement alignment promotes affiliation.

Table 1
Interpersonal Movement Types Characterised in Terms of Temporal and Topological Alignment

	Description	Temporal alignment	Topological Alignment
Synchrony	Co-actors conduct the same movements at the same tempi, at the same time	Yes	Yes
Paired Action	Co-actors conduct different movements at the same tempi, at the same time	Yes	No
Asynchrony	Co-actors conduct the same movements at different tempi, at the same time	No	Yes
Turn-Taking	Co-actors conduct the same movements at the same tempi, but with movement onset temporally offset; *similar to mimicry*	Partial (tempi matched; non-concurrent)	Yes

1.2.1 Reasonable doubt about the alignment→affiliation link. That synchrony and mimicry both involve interpersonal alignment and lead to similar affiliative outcomes has led researchers (especially in the case of synchrony; e.g., Smith, 2008) to speculate that interpersonal alignment produces a physical self–other overlap that generalizes to psychological self–other overlap. The general idea is that interpersonal alignment supports multisensory integration of signals from self and other. During interpersonal alignment, the individual receives a variety of sensory inputs: visual and auditory input from their own and their co-actors' movement, as well as proprioceptive feedback from their own movement (although other inputs, such as tactile, are also possible). To the extent that a co-actor's movement matches one's own movement temporally and topologically,[1] the diverse sensory signals are more likely to be processed as redundant and therefore integrated rather than segregated—in effect, with the brain processing "self" and "other" as one.

Despite the intuitiveness of this account, however, there exists no direct evidence that synchrony and mimicry promote self–other overlap. Moreover, the fact that synchrony (relative to asynchrony) and mimicry (relative to its absence) evoke apparently similar affiliative responses actually poses a problem when interpersonal movement alignment is decomposed into temporal and topological components. Synchrony is characterised by both topological and temporal alignment. That is, it consists of co-actors performing the same movements at the same time. In contrast, both asynchrony and mimicry exemplify topological alignment but temporal *misalignment*—that is, the same movements conducted at a different time. For example, in research into the effects of synchrony, asynchrony is often induced via the entrainment of co-actors' movements to temporally mismatched cues (e.g., Hove & Risen, 2009). Similarly, imitative movements cannot, by their very nature, be conducted at the same time as the movements that they imitate; the experimenter simply observes a target movement being conducted by their participant and, at an undefined subsequent time, performs the same movement.

Yet if action representations are translated directly into social outcomes, then how can temporally mismatched movements engender affiliation in one instance (mimicry) but fail to do so in another (asynchrony)? The fact that synchrony and mimicry both evoke affiliation suggests that the social effects of like-movements

[1] Multisensory integration should also be facilitated by spatial alignment. We do not consider this dimension in the research reported in this thesis because we assume that *interpersonal* movement requires spatial proximity.

either arise as a function of distinct mechanisms or do not arise directly from the structure of the movements themselves (i.e., the degree of temporal and topological alignment present).

1.2.1.1 Efficiency-oriented processing. That synchrony implicates two dimensions of alignment whereas mimicry implicates only one suggests that multisensory integration of self and other might be more efficient for synchrony than mimicry. If actions elicit activation in the same networks as those implicated in observing a synchronous, asynchronous, or a turn-taking partner, observing an action that is identical to one's own and is performed at the same time should require fewer representational resources than observing a different action (during paired action; see Table 1) or observing the same action at a different time (as in the cases of asynchrony and turn-taking). This is so because an unknown percentage of the observer's motor networks would be activated simultaneously for both the actor's own and their co-actor's actions during synchrony and not paired action, or because the motor network activation pattern would be more similar during synchrony than asynchrony or turn-taking. Hence, synchrony ought to employ fewer representational resources than forms of interpersonal movement that are aligned on fewer dimensions. As a result, synchrony should be more efficient than asynchrony, paired action, or turn-taking. Similarly, asynchrony, paired action, and turn-taking, by virtue of having one dimension of alignment, should be more efficient than an interaction without interpersonal movement and thus no movement alignment.

These processing efficiencies should also have implications for affiliation. Research elsewhere has shown that processing fluency is associated with positive evaluation (Reber, Schwarz, & Winkielman, 2004; for a review, see Alter & Oppenheimer, 2009) and positive affect (Winkielman, & Cacioppo, 2001). Based on the above reasoning, synchrony should evoke more affiliation than asynchrony, paired action, and turn-taking, and these forms of interpersonal movement should evoke more affiliation than an interaction without interpersonal movement.

2. Overview of the Thesis

The impact of different dimensions of alignment on affiliation has not yet been researched, and no research has compared different forms of interpersonal movement. Indeed, in the foregoing review, I have focused only on the effects of (a)synchrony and mimicry. This is because relatively little is known about the affiliative outcomes of joint or "paired" action—the performance of different actions with the same temporal structure (temporal alignment with topological misalignment). Instead, investigations of joint action have focused largely on how own and others' actions are represented and hence how joint action is achieved (e.g., Loehr, Kourtis, Vesper, Sebanz, Knoblich, 2013; Vesper, Knoblich, & Sebanz, 2014; cf. Tarr et al., 2015). Yet comparing synchrony and asynchrony with paired action—manipulating topological and temporal alignment separately—enables inferences about the independent contributions of each dimension. Doing so therefore enables inferences about the importance of alignment in general.

The research reported in this thesis was designed to investigate which mechanisms are responsible for the affiliative consequences of interpersonal alignment—and why synchrony promotes affiliation.

I report three experiments. In Chapters 2–4, I report a series of experiments in which participants engaged in an interpersonal movement task with a co-actor (another participant) before completing measures designed to assess feelings of affiliation and to test self–other overlap as a mechanism for the affiliative effects of interpersonal movement. Across all three experiments, temporal and topological alignment were also examined systematically, to explore their separate contributions to the affiliative effects of interpersonal movement. Two objective measures of kinematic performance (digital and inertial) were also acquired, providing additional insight into the relationship between actual interpersonal alignment and affiliation.

In Chapters 2–3, participants performed a series of arm movements with a partner that were aligned temporally (paired action), topologically (asynchrony), or on both dimensions (synchrony). To approximate mimicry, participants in a turn-taking condition made the same movements as their co-actor during their co-actor's inter-trial intervals.[2] To control for possible effects of the movements themselves, participants in a baseline condition (back-to-back) completed the same task while facing away from their co-actor.

In Chapter 2, I explored whether co-representation—the simultaneous and linked representation of self and co-actor—mediates the affiliation levels evoked by movement condition. Following an interpersonal movement task, participants completed a joint Simon task (Sebanz, Knoblich, & Prinz, 2003). In Chapter 3, I explored both perceived alignment and interpersonal projection—ascribing one's own characteristics to another person—mediates the alignment–affiliation link. Following the same interpersonal movement task, participants reported on their own personality and their perceptions of their co-actor's personality, and the correspondence between the two was taken as a measure of interpersonal projection.

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[2] Though, strictly speaking, this turn-taking condition was not mimicry, it was intended to act as a physical manifestation of mimicry in that one actor's movements replicated the other's after a delay. By restricting participants to entrain their movements to an external cue, the leader-follower dynamic that characterizes true mimicry was absent in this experiment.

In the third experiment (Chapter 4), the nature of alignment was manipulated yet further. Participants performed movements that were misaligned across dimensions in order to examine the effects of misalignment on affiliation, as well as the stability of the effects reported in Chapter 3 across alignment types.

To summarize, the research was guided by two goals: First, I sought to test self–other merging (via co-representation and interpersonal projection) as a candidate mechanism for the affiliative effects of interpersonal movement (and explored other possible mechanisms as suggested by the data). Second, I explored the separate contributions of temporal and topological alignments in the emergence of these effects.

CHAPTER 2: ACTION CO-REPRESENTATION AS MEDIATOR OF THE AFFILIATIVE EFFECTS OF ALIGNMENT DURING INTERPERSONAL MOVEMENT

The current chapter examined the affiliative effects of temporal and topological interpersonal movement alignment. In this experiment, participants in dyads (N = 182; 86 dyads) aligned their arm movements to an auditory cue; random assignment of movement type and cue timing created interpersonal movement that was synchronous (temporally and topologically aligned), paired (temporally aligned, topologically misaligned), or asynchronous (temporally misaligned, topologically aligned), or involved turn-taking (temporally non-aligned, topological aligned) arm movements. Control participants made matched movements while facing away from their co-actor (back-to-back baseline). To enable testing for mediation by action co-representation, participants then completed a joint Simon task before completing questionnaires assessing affiliation with the co-actor. Synchrony evoked greater levels of affiliation than all other conditions except turn-taking; no other between-condition differences in affiliation were observed. The joint Simon effect was robust, but was neither affected by movement condition nor predictive of affiliation levels. Furthermore, the pattern of affiliation levels evoked by each movement condition differed from that which would be expected if action co-representation mediated outcome. Our results do not support the idea that self–other merging—at least as operationalised via action co-representation—is responsible for the affiliative effects of alignment during interpersonal movement.

1. Introduction

As outlined in the review in the previous chapter, the relative affiliative effects of synchrony (temporal and topological alignment) and asynchrony (temporal misalignment and topological alignment) are well documented (e.g., Tarr, Launay, Cohen, & Dunbar, 2015; Wiltermuth & Heath, 2009). However the affiliative outcomes of other movement types, such as paired action (temporal alignment and topological misalignment), are less understood. Moreover, the mechanisms underpinning the affiliative effects elicited by alignment are underspecified. Self–other overlap has been suggested as one such mechanism (e.g., Smith 2008), but no direct evidence for the suggestion exists. Common coding theory provides a promising basis for one possible self–other overlap mechanism: action co-representation. An aim of the present experiment was to test whether action co-representation is responsible for mediating the affiliative effects of alignment.

1.1 Common Coding and Action Co-Representation

The common coding account posits that actions are encoded in terms of their effects (Prinz, 1984; 1997); that is, actions and outcomes share a “common code” (Hommel, Müsseler, Aschersleben, & Prinz, 2001; see also Ideomotor Theory: Greenwald, 1970; James, 1890). Hence, when networks that encode movements are activated, the representations of the expected outcomes of the action are simultaneously and proportionally activated (Knoblich & Flach, 2001). There is also evidence for the reverse scenario: Perceiving events in the environment (e.g., reminiscent of a given action outcome) triggers the representation of the relevant action (Etzel, Gazzola, & Keysers, 2008).

However, since the same representational systems represent action execution, simulation and observation, the principles of common coding can also be extended to others' actions (co-representation; Knoblich & Sebanz, 2006; Sebanz, Bekkering, & Knoblich, 2006). Indeed, our social world may require that we efficiently encode others' actions, intentions and goals along with their effects (Bloesch, Davoli, Roth, Brockmole, & Abrams, 2012). This mechanism means for example that we are better able to play a game of table tennis if we can see the body of the co-actor when the ball is invisible (Streuber, Mohler, Bülthoff, & de la Rosa, 2012). Actions are facilitated if they have previously been observed and are impaired if the observed action is different (Brass, Bekkering, & Prinz, 2001), just as enacted behaviours are more likely to be replicated by their observer (Chartrand & Bargh, 1999).

Evidence for such a system can be found in part in the fact that the effects of an action–perception coupled system, as extended to others, impacts performance. When two participants work simultaneously to complete a cognitive task where each participant is responsible for one task component, their performances more closely resemble their performance when they are individually responsible for both task components, than their performance when they are responsible for only one task component. That is, they act as if they are responsible for both task components even when they are not, so long as they are aware that a co-actor is responsible for the other task component (Sebanz, Knoblich, & Prinz, 2003).

One such example is derived from the Simon task. In the Simon task, participants are required to make spatially specific responses (e.g., press the "L" versus the "A" key on a computer keyboard) to stimuli whose spatial location can be varied (Simon, 1969). Participants make one spatially specific response (e.g., press the "A" key on the left hand side of the computer keyboard) for one stimulus type (e.g., a blue circle) and another spatially specific response (e.g., press the "L" key on the right hand side of the computer keyboard) for another stimulus type (e.g., a red circle). Stimuli are randomly presented on either the left or the right hand side and so are spatially congruent or incongruent with their required response locations (e.g., on the left or the right hand side of the computer keyboard). Response times to stimuli that are spatially congruent with their designated response location are faster than responses to stimuli that are spatially incongruent with their designated response location. In contrast, when participants make only one response to one of the two presented stimuli (e.g., responding only to blue circles and ignoring red circles), their response times are not affected by the spatial congruency of stimulus and response. Rather, response times are the same for the stimulus, irrespective of whether it is presented on the same or the opposite side of the required response location (for review see Hommel, 2011).

The interference effect present for the dual-response version of the task, and which is driven by stimulus–response congruency, can also been elicited for the single response version if a co-actor takes part. In the joint version of the Simon task, participants sit side by side facing a computer monitor (Sebanz, Knoblich, & Prinz, 2003). Each participant responds to only one of the two stimulus types (e.g., blue or red circles), making only one of the two available responses. For example, participants seated on the left hand side may make responses to blue circle stimuli by pressing the “A” key on the left hand side of a computer keyboard, and participants seated on the right hand side may respond to only red circle stimuli by pressing the “L” key on the right hand side of the same keyboard. Each participant therefore responds to different stimuli, by making a separate spatially located (e.g., button press) response. As in the single-person version of the task, stimuli are presented either in the left or the right hand side of the screen and so may be congruent or incongruent with the location of the required response participant. In principle, each participant is each engaged in a single response version of the original Simon task, albeit alongside a co-actor. In spite of this, their response times for stimuli presented on the contralateral side of the screen are longer than to those which are spatially congruent with (i.e., presented on the same side as) the required response. And so, participants' responses typify those for the dual-response version of the single-person version of the task (Sebanz, Knoblich, & Prinz, 2003). The authors argue that this go/no-go effect (the joint Simon effect) supports the notion that actors represent the actions of their co-actors as they do their own (Sebanz, Knoblich, & Prinz, 2003; see also: Sebanz, Knoblich, & Prinz, 2005).

Importantly for the purposes of the present experiment, individuals' ability to map their co-actors' actions onto their own action representation networks may also play a significant role in social function more broadly. Perception–action coupling may enable an observer to gain insight into their partner's intentions and emotional states (Blakemore & Decety, 2001), and this common representational system may even play a crucial role in empathy (Preston & de Waal, 2002). Action co-representation, as measured with the joint Simon task, has also been shown to be responsive to social factors such as the abrasiveness of the co-actor (Hommel, Colzato, & van den Wildenberg, 2009) or whether co-actors are members of an outgroup (Müller, Kühn, van Baaren, Dotsch, Brass, & Dijksterhuis, 2011). With respect to group membership, one experiment demonstrated that although white participants co-represented a white virtual hand, they showed no such effect for a non-white equivalent (Müller et al., 2011, Experiment 1). Yet for those participants asked to read a story forcing them to adopt the perspective of a Surinamese protagonist, co-representation for the black virtual partner was established (as compared to a white protagonist; Müller et al., 2011, Experiment 2). Given these findings, the degree to which action co-representation occurs seems not only to influence interpersonal function (e.g., insight into other's intentions), but to be modulated by the nature of the relationship itself.

In sum, through common coding and action–perception links, joint action is expected to elicit co-representation. Thus, interpersonal movement alignment, in involving temporally associated action, should similarly elicit co-representation. Moreover, the degree of co-representation seems to be responsive to extra-task factors (e.g., pre-task abrasiveness; Hommel et al., 2009). This raises the interesting question of whether the degree of alignment would also influence the degree of co-representation.

Considering our taxonomy of alignment (Table 1), it seems reasonable to expect synchrony to elicit stronger co-representation than other forms of interpersonal movement, simply because it is the only form of interpersonal movement characterised by full alignment. The relative effects of the remaining forms of movement in our taxonomy are less clear. Multisensory integration, to the extent that it creates neural "gestalts", should facilitate co-representation. To the extent that own and other actions are contiguous temporally and topologically, the neural signals corresponding to the own and other representations should be integrated. Paired action and asynchrony are characterised by one form of alignment each (temporal and topological alignment, respectively) but also one form of misalignment, and it is not clear whether temporal or topological alignment, if either, should be expected to takes precedence. Intuitively, it seems as if it would be "easier" to represent the same action twice (asynchrony) rather than to represent two different actions (paired action); however, current discussions of multisensory integration do not specify a hierarchy of influence for temporal, topological, and spatial contiguity, and so this remains mere speculation. Finally, turn-taking—our simplified version of mimicry—is characterised by topological alignment, but its status in terms of temporal alignment is unclear: At the level of the movement itself, it may be matched in terms of the tempo of that movement; more globally, however, because of the delayed onset between self and co-actor, it is also characterised by temporal non-overlap (i.e., concurrency).

1.2 Overview

In the current experiment, participants performed a series of arm movements with a partner that were aligned temporally (paired action), topologically (asynchrony), or on both dimensions (synchrony). To approximate mimicry, participants in a turn-taking condition made the same movements as their co-actor during their co-actor's inter-trial intervals. To control for possible effects of the movements themselves, participants in a baseline condition (back-to-back) completed the same task while facing away from their co-actor. Participants then completed a joint Simon task, to enable us to assess co-representation (i.e., self–other overlap). They then completed measures assessing their sense of affiliation with their co-actor. In doing so, we investigated whether alignment influences affiliation via co-representation (aka self–other merging).

Based on past research, we hypothesised that self-reported affiliation would be higher following synchronous than asynchronous movement and following turn-taking than a baseline condition. Based on the foregoing analysis regarding multisensory integration and common coding, we hypothesised that co-representation effects would be stronger in the synchrony condition than all other conditions. We did not have clear predictions for the remaining comparisons for either self-reported affiliation or co-representation. Given the lack of attention in the literature to separating movement alignment into its temporal and topological dimensions and the lack of clear evidence that one dimension should take precedence of the other, we sought to explore the patterns that emerged from the data.

2. Method

2.1 Participants and Design

Participants were 182 undergraduate psychology students (164 female; mean age = 19.09 years) at the University of Birmingham who completed the study in exchange for course credit. The experiment used a single-factor (Movement Condition: synchrony, paired action, asynchrony, turn-taking, back-to-back [B2B] baseline) between-participants design.

Sample size (for this experiment and the experiments reported in Chapters 3–4) was determined based on the effect size calculated from a previously published study linking synchrony to rapport (Hove & Risen, 2009, Experiment 2, $d = 0.74$). The analysis was conducted using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007). The minimum acceptable total sample size needed to achieve a power level of .80 for a five-group between-participants design was determined to be 150.

In accordance with ethical approval, all participants received information on the experimental procedure and gave informed consent prior to participating. Following the completion of all tasks, participants were debriefed and compensated accordingly.

2.2 Apparatus

Auditory stimuli for the interpersonal movement task were created using Reaper Digital Audio Workstation V5 (www.reaper.fm). These were presented to each participant through noise-cancelling headphones connected to a computer, running Windows Media Player (Microsoft, Washington), via stereo-mono-stereo splitter. Questionnaires were administered on two Toshiba laptop computers (Toshiba, Tokyo).

To permit analysis of participants' kinematics, two synchronized inertial displacement monitors (Opals; APDM, Portland, OR) were fitted to the wrists of each participant's active arm. These were set to stream wirelessly, sampling at a rate of 128 Hz, to a computer running Mobility Lab (APDM; Portland, OR). A digital camera (Sony, Tokyo) was also set to record for the duration of the movement task at a sampling rate of 25 fps. The camera was affixed to a tripod and orientated in such a way that it captured both participants' movement from a side view.

2.3 Stimuli

The stimuli were created from auditory cues in the form of spoken letters "A" to "G" (500 ms duration). These letter referents were recorded individually in Reaper Digital Audio Workstation, and background noise was removed with a Noise Gate VST (GVST; freemusiciansresource.com). The stimuli consisted of stereo-combined monophonic files.

These stimuli were combined into two different arrangements of audio cues (Seq1, Seq2; see Appendix A), each comprised of 84 letters; no two consecutive stimuli matched. Each letter arrangement was duplicated and inter-stimulus intervals (ISIs) were set to 1000 ms for one duplicate and 1300 ms for the other (ISI "fast" and "slow", respectively), yielding four sequences in total (Seq1fast, Seq1slow, Seq2fast, Seq2slow). Silent periods (3000 ms for "fast" strings and 3900 ms for "slow" strings) were inserted after every third stimulus, creating stimulus triplets with duration-matched rest periods. Condition-specific stimuli were then constructed by aligning and "panning" these strings separately to either the left or right headset as follows (see Figure 1).

2.3.1 Synchrony. Stimuli and ISIs were matched, and stimulus triplet onsets were aligned (resultant stereo files produced from the following mono files: Seq1fast

× Seq1fast, Seq1slow × Seq1slow, Seq2fast × Seq2fast, Seq2slow × Seq2slow; see Figure 1). In other words, co-actors made the same movements, at the same tempi, at the same time.

2.3.2 Paired action. Stimuli were mismatched, ISIs were matched and stimulus triplet onsets were aligned (resultant stereo files produced from the following mono files: Seq1fast × Seq2fast, Seq2fast × Seq1fast, Seq1slow × Seq2slow, Seq2slow × Seq1slow; see Figure 1). In other words, co-actors made different movements, at the same tempi, at the same time.

2.3.3 Asynchrony. Stimuli were matched and ISIs misaligned. As a result, stimulus triplet onsets were also misaligned (i.e., mono files: Seq1fast × Seq1slow, Seq1slow × Seq1fast, Seq2fast × Seq2slow, Seq2slow × Seq2fast). To enable stimulus mismatch, stimulus strings were duplicated. Rest periods were increased to 4800ms for half of the "fast" duplicates (S1fastincr, S1fast, S2fastincr, S2fast), and decreased to 2100ms for half of the "slow" duplicates (S1slowdecr, S1slow, S2slowdecr, S2slow). To maximise temporal mismatch between stimuli, the onset for "slow" strings was subjected to a 150ms delay (i.e., resultant stereo files produced from the following mono files: S1fastincr × S1slow, S1fast × S1slowdecr, S2slowdecr × S2fast, S2slow × S2fastincr; see Figure 1). In other words, co-actors made the same movements, at different tempi, with overlapping movement onset.

2.3.4 Turn-taking. The stimuli were identical to those used in the synchrony condition, with the exception that the onsets of stimulus triplets in one string were aligned with the rest period onsets in the other (resultant stereo files produced from the following mono files: Seq1fast × Seq1fast, Seq1slow × Seq1slow, Seq2fast × Seq2fast, Seq2slow × Seq2slow). As a result, stimulus triplet onsets were misaligned, falling during rest onsets for the other string (see Figure 1). In other words, co-actors made the same movements, at the same tempi, but with no movement timing overlap.

2.3.5 Back-to-back (B2B) baseline. The stimuli were identical to those used in the synchrony condition (see Figure 1). In other words, co-actors made the same movements, at the same tempi, and the same time, but with no visual access to one another.

Two stimuli blocks, each of a different duration, were therefore produced for each condition: 214.5 seconds (for "slow" strings) and 165 seconds (for "fast" strings) for all conditions except asynchrony (for "slow" strings = 214.65 sec; for "fast" strings = 165.15 sec) and turn-taking (for "slow" strings = 218.4 sec; for "fast" strings= 168 sec).

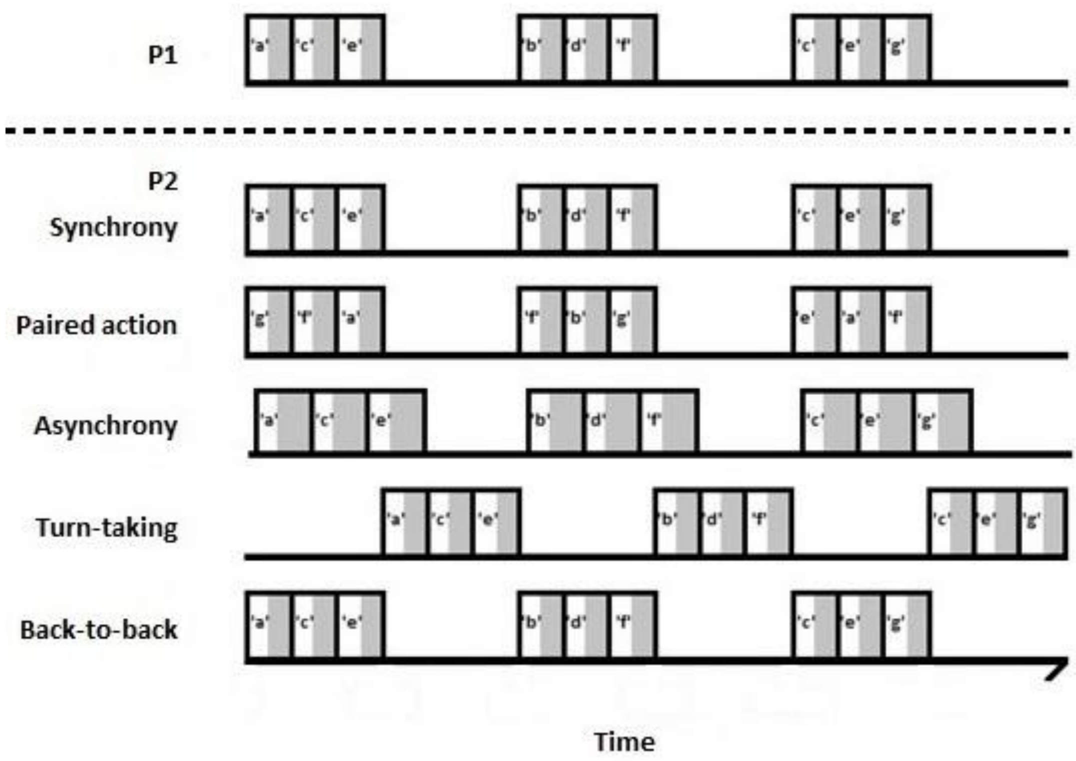

Figure 1. Schematic portraying temporal relationships between the audio stimuli presented to each participant (participant one: P1; participant two: P2) for each condition. *Note.* Grey areas denote silent periods within stimulus triplets.

2.4 Procedure

Participants completed the study in pairs. Participants volunteered to complete a study titled “Point It Out.” Upon arrival at the laboratory, all learned that the goal of the study was to investigate “people’s movement in the presence of others”. Participants were directed that, because this was an investigation into movement they should minimise their communications with each other.

2.4.1 Interpersonal movement task. For the movement task, participants stood facing each other (1 metre apart) and made arm movements timed to the auditory cues (i.e., the spoken letters “A” to “G”). Participants were informed that they would hear a series of letters through their headsets. Starting with the active hand (right hand for Participant 1 (P1), left hand for Participant 2 (P2)) positioned in front of the centre of the chest, participants were told to move their hand to the position corresponding to the letter cue and back. Arm movements (see Figure 2) ended in the same vertical plane as the body. Hence, for the letter stimulus, “F”, participants unfolded their arm from the centre of the chest moving the hand away from the body until it was fully outstretched, keeping it in the same plane as the start position. For the letter stimulus, “B”, participants moved their hand and arm across the chest (i.e., cross-trunkal), again, keeping it in the same horizontal plane as the start position. The response to the letter, “G”, consisted of unfolding the arm downwards until the hand was positioned to the right of the right leg. As with, “B”, responses to the letter, “A”, were also cross-trunkal, and ended with the hand positioned to the left of the left leg.

The experimenter oriented participants to illustrations of each movement, and demonstrated each movement. The arm movements were the semaphore positions representing the letters A to G. Unlike true semaphore, however, these were completed with one arm only, and therefore consisted of three cross-trunk arm movements (see Figure 2). After each example provided by the experimenter, participants also completed the movement, thereby ensuring that they were able to complete the task. Participants were instructed to attempt to complete each movement in time with the respective auditory letter stimulus.

Participants then donned their respective pair of noise cancelling headphones to begin the task. Participants completed the arm movements in triplets, hearing three spoken letters and making three arm movements in each trial; rest breaks were inserted between each movement triplet. Two laminated A3 reference sheets, which displayed the movement endpoints that corresponded to each audio-stimulus (letters A to G; see Figure 2), were placed on the walls behind each participant, high enough to be viewed by the other participant.

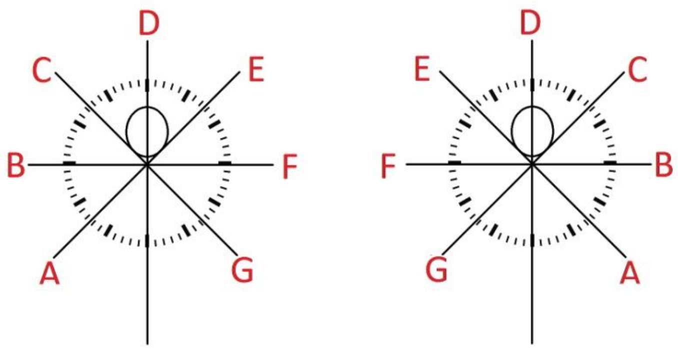

Figure 2. A3 referent sheets displayed to each member of the dyad (participant 1 = left; participant 2 = right) in the interpersonal movement task. Letter positioning depicts the required movement endpoints for each audio stimulus.

Arm movements were spatially matched such that one participant was assigned to move their left arm and the other to move their right arm. Dyads were further assigned randomly to one of five conditions. Participants in the synchrony, paired action, asynchrony, and turn-taking conditions completed the task while facing one another; participants in the movement-only baseline (back-to-back baseline) completed the task while standing back-to-back.

2.4.2 Dependent measures.

2.4.2.1 Joint Simon task. When the interpersonal movement task was complete, dyads were led to a testing room to receive instructions on how to complete the joint Simon task (Sebanz, Knoblich, & Prinz, 2003).

Participants were seated side by side facing a computer monitor. For the task's duration they made their responses via a shared computer keyboard as follows: Those seated on the right hand side responded to blue stimuli only, by pressing the "3" key with the index finger of their right hand. Those seated on the left hand side responded to red stimuli only, by pressing the "Z" key with the index finger of their left hand. Participants were informed that this was a speeded response task and that they should make their response as soon as their allotted stimulus appeared, irrespective of where it appeared on the screen.

During the task, stimuli consisted of a central fixation cross (duration: 500 ms) followed by either a red or a blue circle (duration 1000ms). Stimulus colour (red/blue) and location (left/right) were pseudo-randomised (24 trials per type, per block). To prevent strategic slowing, “Speed Up” was displayed (duration: 1000ms) if response times exceeded 700 ms. To ensure conscientious participation and minimize pre-emptive responding, “Slow Down” was presented (duration: 1000 ms) if response times were less than 100 ms. A red “X” was presented when participants responded to their co-actor’s stimulus, which was displayed beneath the stimulus until the correct response was made. Participants remained in their allocated seating position throughout, making the same response to the same stimulus across all task blocks. A brief (30-trial-long) practice block preceded the three experimental blocks (96 trials per block).

Once the joint Simon task was complete participants were separated to complete partner ratings questionnaires designed to assess their reactions to their task partner, with one co-actor remaining where they were and the other being directed to another testing room. Participants completed their task and partner ratings on computers using MediaLab and Direct RT research software (Empirisoft Corporation, 2006).

2.4.2.2 Affiliation. Participants completed a version of the Inclusion of Other in the Self measure (IOS; Aron, Aron, & Smollan, 1992). They were presented with seven pairs of circles that varied from complete separation (1) to almost-complete overlap (7) and chose the set that best described how they perceived their relationship with their task partner.

Participants also responded to four items along 7-point scales anchored by 0 (*not at all*) to 6 (*very much*), presented in random order: "How much did you like your partner?", "How much rapport did you feel with your partner?", "How similar did you think you and your partner were?", and "How trustworthy do you think your partner is?"

2.4.2.3. Exploratory items.

2.4.2.3.1 Task meta-judgment: Perceived alignment. Respondents rated the extent to which they felt that their movements during the movement task had been *well coordinated* and *in sync* with their partner's. Both ratings were made along 7-point scales ranging from 0 (*not at all*) to 6 (*very much*). Item order was randomized[3].

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[3] Participants in all conditions made these ratings. I did not analyse the responses of participants in the B2B condition, because they had no basis for making these judgments and so it would be difficult to interpret their meaning. I did, however, use the responses in the mediation analyses in Experiments 2–3, as I needed a baseline for dummy coding movement condition.

2.4.2.3.2 Task enjoyment. Participants reported how much they enjoyed the arm movement task along a 7-point scale ranging from 0 (*not at all*) to 6 (*very much*).

2.4.2.3.3 Energy. Participants rated how they felt during the movement task using a 7-point scale ranging from 0 (*exhausted*) to 6 (*energised*).

2.4.2.3.4 Awareness. Participants responded to two items targeting how aware they were of themselves and their own movements (self-awareness) and of their surroundings (environment awareness) during the movement task. Each rating was made on a 7-point scale ranging from 0 (*not at all*) to 6 (*very*).

2.4.2.3.5 Partner helpfulness and *distraction.* Participants assessed how *helpful* and *distracting* their partner's movements were during the movement task along two 7-point scales, from 0 (*not at all*) to 6 (*very*).

2.4.2.3.6 Mood. Participants rated their current mood along a 7-point scale from -3 (*extremely negative*) to +3 (*extremely positive*).

2.4.2.3.7 Effort. Participants reported how much *effort* they put into the movement task on a 7-point scale from 0 (*none at all*) to 6 (*very much*).

Finally, participants provided basic demographic information (i.e., age, sex, first language, and current level of study).

3. Results

Descriptive statistics are presented in Table 2. Unless otherwise indicated, all measures were analysed using single-factor (Movement Type: synchrony, paired action, asynchrony, turn-taking, B2B) analyses of variance (ANOVAs).

Table 2

Self-Report Measure Means [and 95% CIs] as a Function of Movement Condition, Experiment 1

	Synchrony (n = 38)	Paired Action (n = 36)	Asynchrony (n = 36)	Turn-Taking (n = 36)	Back-to-Back (n = 36)
Main measures					
Affiliation	3.92 [3.64, 4.19]	3.30 [3.02, 3.58]	3.49 [3.21, 3.77]	3.64 [3.36, 3.93]	3.29 [3.01, 3.57]
Joint Simon: incongruent trial RTs (ms)	338.93 [329.07, 348.79]	338.26 [328.13, 348.39]	333.31 [323.18, 343.44]	343.67 [333.54, 353.80]	342.87 [332.74, 353.00]
Joint Simon: congruent trial RTs (ms)	327.10 [317.66, 336.55]	326.54 [316.84, 336.24]	320.92 [311.21, 330.62]	330.94 [321.24, 340.64]	330.00 [320.29, 339.70]
Joint Simon effect (ms)	11.83 [8.48, 15.18]	11.72 [8.27, 15.16]	12.40 [8.95, 15.84]	12.73 [9.29, 16.18]	12.88 [9.43, 16.32]
Exploratory measures					
Perceived alignment	4.34 [4.05, 4.82]	2.38 [1.98, 2.77]	3.17 [2.78, 3.56]	2.61 [2.20, 3.00]	1.78 [1.37, 2.18]
Task enjoyment	3.79 [3.41, 4.17]	3.28 [2.89, 3.67]	3.67 [3.28, 4.06]	3.36 [2.97, 3.75]	3.19 [2.80, 3.59]
Energy	3.42 [3.14, 3.71]	2.95 [2.66, 3.23]	3.14 [2.85, 3.43]	3.06 [2.77, 3.35]	3.31 [3.02, 3.60]
Self-awareness	4.63 [4.28, 4.99]	4.33 [3.97, 4.70]	4.31 [3.94, 4.67]	4.14 [3.78, 4.51]	4.81 [4.44, 5.17]
Environment- awareness	2.24 [1.87, 2.61]	1.92 [1.54, 2.30]	2.67 [2.29, 3.05]	2.17 [1.79, 2.55]	2.14 [1.76, 2.52]
Partner helpfulness	4.26 [3.81, 4.72]	1.61 [1.15, 2.08]	3.44 [2.98, 3.91]	2.58 [2.12, 3.05]	0.72 [0.26, 1.19]
Partner distraction	2.45 [2.02, 2.88]	2.67 [2.23, 3.11]	3.33 [2.89, 3.77]	2.72 [2.28, 3.16]	0.31 [-0.13, 0.75]
Mood	1.13 [0.79, 1.47]	0.83 [0.49, 1.18]	0.75 [0.40, 1.10]	0.69 [0.35, 1.04]	0.86 [0.51, 1.21]
Effort	5.74 [5.42, 6.05]	5.58 [5.26, 5.91]	5.14 [4.81, 5.46]	5.11 [4.79, 5.44]	5.61 [5.29, 5.94]

Note. Possible range = 0 to 6 for perceived alignment, affiliation, energy, awareness, task enjoyment, effort; -3 to +3 for mood, perceived helpfulness. Joint Simon effect = $RT_{incongruent} – RT_{congruent}$.

3.1 Joint Simon Task

Unlike in past research, the joint Simon scores were calculated separately for each participant (i.e., at the individual level rather than dyad level); this was done to allow for follow-up analyses examining the relationship between participants' performance on the joint Simon task and their individual ratings of their task partner and other aspects of the experimental tasks. Trials were coded as "congruent" when they appeared on the side of the computer screen adjacent to the participant's seating position and "incongruent" when presented to the alternate side.

Mean response latencies served as the dependent measure of interest. Given the presence of outlying responses in the data set, response times that were more than 2.5 standard deviations from the mean were excluded from the analysis, as were trials on which errors were committed. This resulted in 0.97% of the data being excluded from the statistical analysis.

These data were subjected to a 2 (Trial Type: Congruent, Incongruent) × 5 (Movement Condition: synchrony, paired action, asynchrony, turn-taking, back-to-back) mixed-model ANOVA with trial type as a within-participants factor. The analysis yielded only a main effect of trial type, $F(1, 177) = 251.69$, $p < .001$, $\eta_p^2 = .587$, such that participants were slower to respond to incongruent than congruent trials (M = 339.41 ms and 327.10 ms, respectively). There was no difference between movement conditions, $F\ (4, 177) = .09$, $p = .99$, $\eta_p^2 = .002$. Furthermore, Bayesian analysis supported this null finding, indicating that the movement condition effect was 51.10 times more likely to reflect the null (no group difference) than the alternative hypothesis. Hence, though the joint Simon effect was present, it was not affected by movement condition.

3.2 Self-Report Measures

3.2.1 Affiliation. To create an index of *affiliation*, we averaged across *IOS*, *liking*, *rapport*, *perceived similarity*, and *trust* items (Cronbach's $\alpha = .74$).

The ANOVA yielded an effect of movement condition, $F(4,177) = 3.49$, $p < .01$, $\eta_p^2 = .073$. Synchrony evoked greater affiliation than all other conditions (all $p < .02$), except turn-taking ($p = .11$). None of the other conditions differed from each other (all $p > .11$).

The contrast between the synchrony and asynchrony conditions corroborates previous findings on the relative advantage for synchrony over asynchrony. The contrast between the synchrony and paired action conditions suggests further that temporal alignment alone does not account for the beneficial effects of synchrony.

Interestingly, affiliation ratings did not differ between the paired action and asynchrony conditions ($p = .39$), suggesting that temporal and topological overlap have equivalent effects. However, Bayesian analysis revealed that affiliation levels in paired action and asynchrony were only 2.97 times more likely to reflect the null effect (no group difference) than the alternative hypothesis—an inconclusive finding.

In other words, alignment on both dimensions (i.e., temporal and topological; synchrony) was associated with greater affiliation than other conditions, whereas alignment on only one dimension (i.e., paired action, asynchrony) led to no discernible increases in affiliation relative to non-observation (B2B).

3.2.2 Exploratory analyses. Several of the self-report items were included without specific a priori hypotheses.

3.2.2.1 Task meta-judgment: Perceived alignment. The extent to which participants reported being in synchrony and coordinated with their task partner were averaged to create an index of perceived alignment ($r = .72$, $p < .001$).

A single-factor (Movement Type: synchrony, paired action, asynchrony, turn-taking) ANOVA yielded an effect of movement condition, $F(3, 142) = 22.38$, $p < .001$, $\eta_p^2 = .32$. Follow-up comparisons revealed that participants reported more perceived alignment in the synchrony condition than in all other conditions (all $p < .001$).

Furthermore, participants also reported more perceived alignment in the asynchrony condition than in the paired action condition ($p = .01$). Thus, although there was no evidence for differential effects of temporal and topological alignment on affiliation, participants appear to have weighted topological alignment as more important than temporal alignment. However neither condition was reported as having been more (or less) aligned than turn-taking (both $p > .06$).

3.2.2.2 Task enjoyment. Task enjoyment was not influenced by movement condition, $F(4, 177) = 1.73$, $p = .15$, $\eta_p^2 = .038$.

3.2.2.3 Energy. Energy levels were not affect by movement condition, $F(4, 177) = 1.74$, $p = .143$, $\eta_p^2 = .038$.

3.2.2.4 Self- and environment-awareness. Self-awareness was not affected by movement condition, $F(4, 177) = 2.15$, $p = .08$, $\eta_p^2 = .046$; nor was environment awareness, $F(4, 177) = 2.01$, $p = .10$, $\eta_p^2 = .043$.

3.2.2.5 Perceived helpfulness. The perceived helpfulness of co-actors was affected by condition, $F(4, 177) = 36.67$, $p < .001$, $\eta_p^2 = .45$. Actors were perceived as more helpful in the synchrony condition than in all other conditions (all $p < .01$). Actors in the asynchrony condition were thought to have been more helpful than those in the turn-taking condition ($p = .02$), who were in turn reported to have been more helpful than in paired action ($p = .01$). Co-actors in all conditions were believed to have been helpful however; all were believed to have been more helpful than in B2B baseline (all $p < .01$).

3.2.2.6 Perceived distraction. The degree to which co-actors were thought to be distracting was influenced by movement condition, $F(4, 177) = 27.11$, $p < .001$, $\eta_p^2 = .38$. Co-actors in all movement conditions were perceived to be more distracting than co-actors in the B2B baseline (all $p < .001$). Co-actors in the asynchrony condition were also thought to be more distracting than in the paired action and synchrony conditions (both $p < .05$). No other comparisons differed (all $p > .07$)

3.2.2.7 Mood. Mood was not affected by movement condition, $F(4, 177) = 0.95$, $p = .44$, $\eta_p^2 = .021$.

3.2.2.8 Effort. The amount of reported effort required to complete the task was not affected by movement condition, $F(4, 177) = 3.16$, $p = .02$, $\eta_p^2 = .07$.

3.3 Kinematic Analysis

3.3.1 Digital video data. Digital data was recorded for approximately half of the participants (n = 94). Inter-frame differences for all were calculated, after filtering to remove high frequency noise, using Ramsayer and Tschacter's (2008) Motion Energy Analysis (MEA) tool. This software subtracts user-identified regions of interest within each image frame from its associated region of interest in the subsequent frame. The standardised result is therefore a measure of the amount of change which occurs in each region of interest (ROI) over successive images.

Two ROIs—one corresponding to each co-actor—were identified within each digital recording. To ensure that the majority of inter-frame differences within each ROI corresponded to arm movements, rather than clothing or subtle postural adjustments, and given the explicit nature of the movements of interest, the threshold for change detection was set to 25 pixels rather than the default setting (15 pixels).

Table 3

Digital Video Measures [and 95% CIs] as a Function of Movement Condition, Experiment 1

	Synchrony (n = 22)	Paired Action (n = 16)	Asynchrony (n = 16)	Turn-Taking (n = 18)	Back-to-Back (n = 22)
Individual mean (px/frm-1)	342.15 [304.17, 380.13]a	333.15 [288.62, 377.69]a	343.95 [299.41, 388.48]a	336.13 [294.14, 378.12]a	378.99 [341.01, 416.97]a
Individual SD (px/frm-1)	442.47 [395.19, 489.75]a	415.68 [360.24, 471.13]a	409.31 [353.86, 464.75]a	369.14 [316.86, 421.41]a	465.14 [417.85, 512.42]a
Cross-correlation (lag 0 sec)	.81a	.71b	.72ab	-.13c	.72ab

Note. Px/frm-1 = inter-frame pixel change. Dissimilar letter subscripts denote differences at $p < .05$

3.3.1.1 Sanity check: Individual means. Since stimuli were manipulated solely in terms of their alignment relative to the co-actor's stimuli (temporally, topologically), the stimuli and tempi presented to participants individually were the same across conditions. As a result, if participants were completing their assigned movements as intended, analysis of digital measures of participants' movements should reveal no temporo-topological difference between conditions. This was the case: Mean inter-frame change did not differ between movement condition, $F(4, 89) = 0.88$, $p = .48$, $\eta_p^2 = .038$, $BF_{01} = 7.36$.

3.3.1.2 Individual SDs. The effect of misalignment might conceivably influence the stability of each participant's movements as well (see Honisch, Cacioppo, & Quinn, in preparation; Honisch, Fraser, Elliott, Cacioppo, & Quinn, in preparation). This would be reflected in the standard deviation, such that less stability would lead to a larger deviation. This was not evident in digital recordings of each participant's temporo-topological standard deviation: Individuals' inter-frame change SD was not affected by movement condition, $F(4, 89) = 2.08$, $p = .09$, $\eta_p^2 = .085$, $BF_{01} = 1.52$.

3.3.1.3 Cross-correlations. When separate ROIs are ascribed to each co-actor, comparisons of the amount of change that occurs in each ROI over successive frames reflects the degree to which co-actors' movements co-occur. Fisher's *r*-to-*z* transformed correlations of the inter-frame change in these separate ROIs served as the measure of comparison. Movement condition influenced the extent to which co-actors' inter-frame change rates corresponded, $F(4, 42) = 27.27$, $p < .001$, $\eta_p^2 = .722$. Synchrony evoked greater inter-frame correspondence than other experimental conditions (all $p < .03$), except asynchrony for which a trend to significance was present ($p = .05$). There was no difference against baseline ($p = .12$). Asynchrony, paired action, and B2B baseline did not differ (all p >.87). And all conditions, including B2B baseline, brought about more inter-frame change correspondence than turn-taking (all $p < .001$).

3.3.2 Inertial motion data. Velocity profiles for 168 out of the 182 recorded movement blocks were successfully extracted and subjected to low pass Butterworth filter. The difference between successive observations were first calculated for the x, y and z dimensions independently. The square root of the sum of squares of the results were then combined across dimensions, forming a single non-directional array–speed. To assess the temporal similarity of co-actors' movements, co-actors' speed profiles were cross-correlated at a lag of 0 seconds (*speed cross-correlation*). To measure individuals' discrete contributions, each participant's mean speed (individual mean speed) and the standard deviation of their speed (individual SD speed) were quantified.

3.3.2.1 Sanity check: Individual means. As with mean inter-frame change, individuals' mean speeds were not affected by condition, $F(4, 163) = 2.00$, $p = .10$, $\eta_p^2 = .047$, $BF_{01} = 2.74$.

3.3.2.2 Individual SDs. The standard deviations of their speeds was not affected, $F(4, 163) = 1.65$, $p = .16$, $\eta_p^2 = .039$, $BF_{01} = 4.64$.

3.3.2.3 Cross correlations. As with co-actors' inter-frame correspondence, Fisher's r-to-z transformed cross-correlations between participants' movement speeds were affected by movement condition, $F(4, 79) = 332.32$, $p < .001$, $\eta_p^2 = .94$ (see Table 4). However the pattern of these differences was not the same. All comparisons revealed differences (all $p < .001$), except for those against paired action, which differed only from turn taking ($p < .001$; all other comparisons $p > .06$), and between B2B and synchrony ($p = .19$).

Table 4

Inertial Motion Measures [and 95% CIs] as a Function of Movement Condition, Experiment 1

	Synchrony (n = 32)	Paired Action (n = 32)	Asynchrony (n = 36)	Turn-Taking (n = 32)	Back-to-Back [n = 36]
Individual mean (m/s)	.021 [.019, .022]a	.022 [.020, .023]a	.022 [.020, .023]a	.019 [.017, .021]a	.021 [.020, .023]a
Individual SD (m/s)	.023 [.021, .025]a	.024 [.022, .026]a	.024 [.022, .026]a	.021 [.019, .023]a	.024 [.022, .025]a
Cross-correlation (lag 0 sec)	.62a	.57ab	.52b	-.35c	.60a

Note. Dissimilar letter subscripts denote differences at $p < .05$.

3.4 Mediation of the Alignment–Affiliation Relationship

Correlations between dependent variables are presented in Table 5. Since the joint Simon effect was neither predictive of affiliation nor influenced by motor condition, it was not put forward for further analysis as a candidate mediator. That is, given that movement condition influenced affiliation and not the joint Simon effect, and that the joint Simon effect did not predict affiliation, the joint Simon effect seems unlikely to mediate the impact of movement condition on affiliation.

Table 5

Correlations between Dependent Measures, Experiment 1

		1	2	3	4	5	6	7	8	9	10
1	Affiliation	-									
2	Joint Simon effect	.05	-								
3	Digital: Co-actor correlation	-.10	.05	-							
4	Digital: Individual mean	-.18	.13	.17	-						
5	Digital: Individual SD	-.17	.15	.31**	.87**	-					
6	Digital: Co-actor SD	-.18	.10	.31**	.21*	.32**	-				
7	Inertial: Co-actor correlation	-.08	-.06	.84**	.05	.22*	.22*	-			
8	Inertial: Individual mean	-.04	.05	-.11	.22*	.29**	.23*	.15	-		
9	Inertial: Individual SD	-.05	.01	-.10	.14	.25*	.19	.19*	.91**	-	
10	Inertial: Co-actor SD	-.08	.05	-.10	.15	.19	.25*	.19*	.42**	.44**	-

Note. “Inertial” and “Digital” refer to the dependent indirect measures of temporality (speed) and topology (number of pixels to change between frames) respectively. $*p < .05$, $**p < .01$.

4. Discussion

The present experiment examined the affiliative effects of temporal and topological alignment on affiliation, and explored one operationalization of self–other overlap (namely, co-representation) as a potential mechanism accounting for the alignment–affiliation link. Dyads completed movements aligned on one (topological: asynchrony; temporal: paired action) or both (synchrony) dimensions before completing a joint Simon task and reporting their sense of affiliation with their co-actor; we also included a condition in which participants took turns making the same movements at the same tempo (turn-taking; somewhat akin to mimicry) and a movement-only control condition (B2B baseline).

4.1 Effects of Temporal and Topological Alignment on Affiliation

Our results revealed that the affiliation evoked by temporo-topological alignment (synchrony) was greater than the affiliative effects of either temporal (paired action) or topological (asynchrony) alignment alone. Hence, alignment on both dimensions elicits greater levels of affiliation than alignment on either dimension independently. In comparing the outcomes of temporal and topological alignment separately, however, we found no evidence for a prioritization of either form: Affiliation was statistically equivalent following paired action and asynchrony.

To date, no research has investigated the relative affiliative outcomes of synchrony, paired action, and asynchrony. In one set of experiments, Hove and Risen (2009) explored the affiliative effects of synchrony, asynchrony, and a non-movement baseline. Synchrony increased affiliation relative to both asynchrony and baseline. Valdesolo and DeSteno (2011) compared perceived similarity, compassion, and helping behaviour elicited by synchrony versus asynchrony; all were increased by synchrony relative to asynchrony. Yet, in synchrony research, temporal alignment is often manipulated while topological alignment is not. In one notable exception groups of participants performed the same or different dance movements in time to music (Tarr et al., 2015). Each participant was presented with instruction cards displaying dance sequences that matched or differed from those presented to other group members. Given that these movements were performed in time to music, the misaligned movement type was equivalent to paired action (temporal alignment, topological misalignment) used in the present experiment, albeit for groups. Self-reported affiliation (IOS, likeability, similarity, connectedness and trust) levels were greater for group members than non-group members following synchrony than paired action. However, even in this unusual example, no condition consisting of misalignment on the other dimension (i.e., temporal: asynchrony) was included. By comparing the affiliative effects of synchrony (temporo-topological alignment) with asynchrony (topological alignment only) and paired action (temporal alignment only), we have been able to explore the affiliative contributions of alignment in general—across dimensions—rather than merely temporal alignment. We found that alignment on both dimensions led to increases in affiliation relative to baseline, while alignment on each dimension independently led to similar levels of affiliation.

The inclusion of control conditions in synchrony research is infrequent, making it difficult to interpret the typical synchrony advantage over asynchrony, for example. In much past research, it was unclear whether the affiliative differences should be attributed to beneficial effects of synchrony, detrimental effects of asynchrony, or both. We found that only one target condition (synchrony) led to stronger affiliation relative to the B2B baseline. Thus, in this experiment at least, the affiliative effects of synchrony appear to derive from the positive effects of alignment;

there was no evidence of a detrimental effect of misalignment. That is, the affiliative effects of all conditions, except synchrony, were equivalent to those obtained by the movements alone (B2B baseline), even though misalignment and alignment were also present (temporal: asynchrony; topological: paired action). Misalignment did not have a detrimental effect on affiliation, and temporal-topological alignment (synchrony) produced an increase in affiliation. However, it is unclear whether in the present experiment this was because alignment was also present in those conditions for which misalignment was present, cancelling out any possibly negative effects of misalignment.

4.2 Mechanisms Accounting for the Alignment–Affiliation Relationship

A key objective of the present experiment was to test action co-representation (a putative index of self–other overlap) as a potential mechanism responsible for the affiliative effects of synchrony. Participants completed a joint Simon task designed to determine whether their response latencies would be affected by the presence of the co-actors. Although we found a robust joint Simon effect, indicative of action co-representation, it was not influenced by movement condition and did not correlate with co-actor affiliation.

These findings contrast with those reported by Hommel et al. (2009) for whom participants completed a joint Simon task with either an abrasive or a polite confederate. Those who completed the task with an abrasive confederate exhibited smaller joint Simon effect durations than participants whose co-actor was a polite confederate. Our non-effect also contrasts with the findings of Müller et al. (2011), who found that by employing a perspective-taking task in which participants adopted the perspective of a Surinamese protagonist, a joint Simon effect could be established where none might otherwise have existed.

Recently, however, alternative accounts of the co-representation-like effects observed in the joint Simon task have been proposed, which suggest that the joint Simon effect may not reflect action co-representation. Over a series of experiments, Dolk, Hommel, Prinz, and Liepelt (2013) tested whether it is possible to observe a joint Simon effect when a variety of objects were positioned where the co-actor would usually make their response. Participants completed the task alongside a waving cat ornament (Experiment 1), a clock with a spinning pendulum (Experiment 2), a digital audio metronome which was turned on (Experiments 3 and 4), and a digital audio metronome which was turned off (Experiment 5). A joint Simon effect was observed in all except the last experiment (Experiment 5), despite the fact that no other person was present in the room with the participant. Taken together, Dolk et al.'s results revealed that even a single inanimate spatial reference presented in the horizontal plane was sufficient to elicit the effect—so long as it provided event-related information and was salient enough to attract attention (e.g., auditory metronome beats). According to Dolk et al., these findings suggest that the joint Simon effect is salience-based rather than innately social (see also Hommel, 1993; Hommel, Müsseler, Aschersleben, & Prinz, 2001).

In other words, the reason why the joint Simon effect has been previously linked with social factors is because they are associated with different saliencies. With this in mind, Hommel et al. (2009) may have obtained their effects because polite and abrasive confederates are differentially salient. Similarly, Müller et al. (2011) may have been able to establish a joint Simon effect for outgroup members following an empathy manipulation by increasing the salience of outgroup members. In the same vein, Ruys and Aarts (2010) manipulated the degree to which co-actors were interdependent versus independent. They found that in the independent condition, in which the co-actor required least attention, the joint Simon effect was also smallest. Our alignment manipulation in the interpersonal movement task was not designed to manipulate salience, but rather temporal and topological alignment, with a view to affecting the ease or efficiency of multisensory integration. We see no reason why the co-actor would be differentially salient across conditions, given that co-actors were required to orientate toward one another in every condition. If the joint Simon effect is sensitive to salience and if our conditions were not differentially salient, then perhaps we simply failed to detect a co-representation effect using this task. Hence, perhaps action co-representation was manipulated by our interpersonal movement paradigm but not detectable with the joint Simon effect.

Another potential limitation of the joint Simon task, at least as it was used here, is that it was completed by participants after the interpersonal movement task and before the administration of questionnaires that assessed affiliation. Though the aim of including the joint Simon task was to determine whether action co-representation mediates the link between interpersonal movement and affiliation, this task was itself nonetheless an interpersonal task (in that it was conducted with the co-actor). That is, the joint Simon task consisted of time that co-actors spent with each other, conducting a task other than the interpersonal movement task. It is therefore possible that the joint Simon task may itself have influenced affiliation levels, reducing or otherwise altering the influence of the prior interpersonal movement task and making its effects on affiliation.

4.3 Conclusion

In this experiment, participants in the synchrony condition reported more affiliation than in B2B baseline and all other conditions except turn-taking. No other target condition led to affiliative change relative to each other, or B2B baseline. The joint Simon effect was not affected by interpersonal movement condition and did not predict affiliation levels. Moreover, we found no evidence that our objective measures of alignment (inter-frame cross-correlation, speed cross-correlation) predicted outcome either, further discrediting the action co-representation link. This experiment has therefore found limited evidence favouring the notion that action co-representation mediates the impact of alignment during interpersonal movements such as synchrony.

CHAPTER 3: INTERPERSONAL PROJECTION VERSUS PERCEIVED ALIGNMENT AS CANDIDATE MEDIATORS OF THE AFFILIATIVE EFFECTS OF ALIGNMENT

The current chapter again examined the affiliative effects of interpersonal movement alignment. The experiment presented in this chapter examined another putative index of self–other overlap (interpersonal projection) as a potential alignment–affiliation mediator, but also considered a meta-judgement variable (perceived self–other alignment). As in Experiment 1, participants (N = 200; 100 dyads) in dyads performed interpersonal movements that were synchronous (temporally and topologically aligned), paired (temporally aligned, topologically misaligned), asynchronous (temporally misaligned, topologically aligned), or involved turn-taking (temporally non-aligned, topological aligned) arm movements. Control participants made matched movements while facing away from their co-actor (back-to-back baseline). Participants then completed measures assessing their perceptions of their own and their partner's personality (to index interpersonal projection) and the degree to which they perceived themselves as aligned with their partner. Judgments of alignment, but not interpersonal projection, mediated the relationship between movement condition and affiliation. These findings provide early evidence for the possible role of high-order meta-judgments in bringing about the prosocial effects of synchrony.

1. Introduction

The most commonly proposed mechanisms for the affiliative effect of synchrony is self–other overlap, based on the reasoning that common coding and multisensory integration lead signals from own and other action representation to be integrated—in a sense, coding self and other as one. In Experiment 1, we tested this reasoning by using co-representation as an indicator of self–other overlap, but did not find supportive evidence. The joint Simon effect that was tested as a candidate mediator in Chapter 2 was not responsive to movement condition and did not predict, much less mediate, the affiliative effects of alignment. As noted in Chapter 2, however, there are at least two reasons to not accept this null effect. First, there is considerable debate as to what the joint Simon effect (our indicator of co-representation) actually assesses. Second, the fact that the joint Simon task requires co-actors to work side-by-side may have made it sufficiently interpersonal as to offset our intended manipulations of temporal and topological alignment, thereby influencing our affiliation measure in undesired ways. The experiment presented in this chapter thus re-examined the affiliative effects of each movement type explored in the previous chapter, replacing the joint Simon task with a different measure of self–other overlap: interpersonal projection; the ascription of one's own traits to another individual. We also considered a second potential mediator of the alignment–affiliation relationship: perceived self–other alignment.

1.1 From Bodily Self to Psychological Self

Though long considered fixed, the human body schema is a highly adaptable set of representational networks: In a now famous experiment, participants observed a rubber hand being stroked while their own, hidden from view, was simultaneously stroked by the researcher (Botvinick & Cohen, 1998). Participants reported a feeling of ownership of the rubber hand, and that it “felt” as if it had become a part of their own body. In subsequent replications of the effect, evidence has also suggested that participants’ involuntary responses to the extra-corporeal body part are consistent with the feelings they report for it (Ehrsson, Wiech, Weiskopf, Dolan, & Passingham, 2007). For example, if the rubber hand is “threatened” with a painful insult (e.g., being stabbed), the participant’s skin conductance response (SCR) typifies that which would occur if their own hand were similarly threatened (Armel & Ramachandran, 2003).

The effect also extends to the rest of the body. In the so-called “body transfer illusion”, participants wear a set of head-mounted visual display goggles that present an image to each lens independently (Petkova & Ehrsson, 2008). These are connected to a pair of cameras positioned over the orbital regions of a life-sized mannequin’s face. Consequently, the participant is presented with a stereoscopic view of the world as if from the mannequin’s perspective. While the participant has their head tilted downward, they are presented with a stereoscopic image of the mannequin’s torso. Both the participant’s and the mannequin’s torsos are then stroked with a metal rod. As with the rubber hand, participants report a sense of ownership for the mannequin’s body (Petkova & Ehrsson, 2008, Experiment 1). As with the rubber hand, their SCR to a perceived threat to the mannequin’s body typifies the involuntary response to threat to the participant’s own (Petkova & Ehrsson, 2008, Experiment 2; Armel & Ramachandran, 2003).

Surprisingly, this bodily ownership effect can even be obtained when the participant is presented with the visual image of their own (real) body from the mannequin’s allocentric perspective. Indeed, the illusion can apparently be maintained during voluntary physical interaction with their true bodily self, as when the cameras are positioned on an experimenter's head and the participant and experimenter shake hands (Petkova & Ehrsson, 2008, Experiment 4). Therefore, the effect may even persist during sensorimotor exchange, rather than merely multisensory stimulation.

In each of the above cases, the inter-sensory (and sensorimotor) cues must be aligned in order to induce the illusion of ownership. That is, visual and tactile cues must be applied to similar spatial locations on both the participant's own and the extra-corporeal body part synchronously or the effect is lost. In general, the central nervous system combines cues across the different sensory modalities in order to better estimate the body's location (Samad, Chung, & Shams, 2015; Ehrsson, Holmes, & Passingham, 2005), and in the above cases, the spatial and temporal co-occurrence of signals for the participant's own body and the extra-corporeal body are integrated and "trick" the individual into experiencing the body as dislocated from its true location.

Importantly, attributions resulting from the multisensory integration of visuo-tactile cues pertaining to the body also influence attributions made at an altogether higher cognitive level than the bodily self. Paladino and colleagues (Paladino, Mazzurega, Pavani, & Schubert, 2010) asked female participants to observe a video of a female confederate being stroked on the cheek whilst they were themselves subjected to either synchronous or asynchronous tactile stimulation of the same facial location (see also Tsakiris, 2008). Participants then rated the degree of perceived ownership that they felt for the confederate's face, and the level of affiliation that they felt with her (using an "Inclusion of the Other in the Self" scale [IOS]; Aron, Aron, & Smollan, 1992). They also made inferences about her personality. Not only did participants feel a greater degree of ownership of the confederate's face following synchronous than asynchronous tactile facial stimulation, but they were also more likely to report feeling psychologically close to her (Paladino, Mazzurega, Pavani, & Schubert, 2010). Indeed analysis revealed that the degree of perceived ownership entirely mediated the degree of affiliation they reported. Moreover, comparisons between the personality traits that participants ascribed to the confederate and those that they ascribed to themselves revealed that participants were more likely to project their own traits onto the confederate following synchronous, rather than asynchronous, stimulation. In other words, synchronous visuo-tactile stimulation reduced the psychological distinction between participants and the confederate. Hence, merging at the level of the perceived bodily self influenced merging at the level of the psychological self, in terms of both psychological closeness (affiliation) and perceived personality overlap.

These experiments suggest that the representations of the bodily and psychological self are functionally connected such that representations of the bodily self can influence representations of the psychological self. Moreover, they imply that this connection may be the means by which the affiliative consequences of multisensory alignment come about. However, whether these particular findings can be extended from passive multisensory stimulation to active sensorimotor alignment remains unclear, as the effect of synchrony on interpersonal projection, has yet to be tested. Nonetheless, they are consistent with findings in the field in which the degree of perceived similarity evoked by motor alignment mediates affiliation (e.g., Valdesolo & DeSteno, 2011).

1.2 Beyond Bottom-Up Mechanisms

In spite of the promising findings produced by Paladino and colleagues (2010), there is reason to question whether increased bodily and psychological self–other overlap arising from alignment could explain the alignment–affiliation link. As highlighted in Chapter 1, synchrony evokes positive affiliative shifts relative to asynchrony, which does not differ from baseline (Chapter 2; Hove & Risen, 2009). And so, topological alignment, along with temporal misalignment, does not increase affiliation. Yet mimicry, which consists of topologically matched movements that are temporally misaligned, also leads to increased affiliation. Yet if alignment is responsible for outcome, how can temporal misalignment be responsible for the reduced levels of affiliation in one instance (asynchrony) and increased levels of affiliation in another (mimicry)? Any intermediary mechanism which translates alignment into affiliation, and is itself affected directly and solely as a function of alignment, is vulnerable to the same contradiction. For example, if alignment leads to increased self-other overlap, and this in turn leads to increased levels of affiliation, then where alignment is less, self-other overlap, and consequently affiliation, would also be less. As a result, asynchrony would again be expected to produce greater levels of affiliation than mimicry. Synchrony and mimicry would not both be expected to promote affiliation.

The fact that synchrony and mimicry have both been reported to evoke increased levels of affiliation suggests that the social effects of like-movements either arise as a function of distinct mechanisms or do not arise directly from the structure of the movements themselves (i.e., the degree of temporal and topological alignment present). So, their effects cannot arise in both cases by the above proposed mechanism whereby bodily overlap with the co-actor leads to increased self–other psychological overlap with the co-actor.

1.3 Self-Other Merging and Meta-Judgments

Given that temporal misalignment undermines affiliation in one case (asynchrony) and not another (mimicry), we propose that a mechanism based on the degree of alignment alone does not account for the affiliative effects of interpersonal movements. For the reasons outlined above, we argue that the affiliative outcomes of alignment cannot be fully explained by a self–other merging mechanism. We suggest instead that task meta-judgments about the *perceived* alignment of an interaction might account for the affiliative outcomes evoked by alignment.

Whereas alignment during synchrony is arguably obvious to the perceiver, we suggest that individuals may also perceive greater alignment (or less misalignment) during mimicry than asynchrony. Both involve topological alignment and temporal misalignment but, importantly, the nature of the temporal misalignment in mimicry is such that co-actors' movements do not co-occur and thus create, for example, movement interference, whereas the temporal misalignment in asynchrony is such that co-actors' movements do co-occur and thus interfere with one another. Consequently, taking turns to perform the same action at the same tempo (turn-taking) might evoke a greater perceived level of synchrony, thereby leading to increased levels of affiliation relative to asynchrony.

If synchronous alignment *per se* is not responsible for the affiliation effects of interpersonal movement, but rather meta-judgments about whether an interaction is aligned, then mimicry, with its absence of movement interference, may be perceived as aligned even though, at the level of the physical interaction, this is not the case. This presupposes that co-actors make online judgments about the perceived alignment of an interaction and that these task meta-judgments predict the degree of affiliation evoked. Both presumptions have yet to be tested. In the present experiment we therefore manipulated temporal and topological alignment during interpersonal movement to determine whether projection and/or meta-judgments (about perceived synchronousness/coordination) mediate the affiliative impact of alignment.

1.4 Overview of the Research

By manipulating the nature of alignment during interpersonal movement, the current experiment sought to investigate which mechanisms are responsible for the affiliative consequences of interpersonal alignment—and why synchrony promotes affiliation.

Though there is reason to believe that the affiliative effects of interpersonal movement (e.g., synchrony) might rely on bottom-up mechanisms as with self–other merging, the structural differences between synchrony and other movement types that evoke similar effects (e.g., mimicry) suggests otherwise. Either the mechanism responsible for affiliative outcomes differs across movement types (e.g., synchrony, mimicry) or it is not reliant on the degree of alignment present during interpersonal movement itself. Contradictions between movement types suggest that the affiliative outcomes of sensorimotor alignment may instead be based on higher-order representations that are not determined solely by alignment. We speculate that a suitable candidate mechanism is the degree of *perceived* alignment in the interaction itself (i.e., interaction meta-judgments).

In the current experiment, as in the previous chapter, participants performed a series of arm movements with a partner that were aligned temporally (paired action), topologically (asynchrony), or on both dimensions (synchrony). To approximate mimicry, participants in a turn-taking condition made the same movements as their co-actor during their co-actor's inter-trial intervals. To control for possible effects of the movements themselves, participants in a baseline condition (back-to-back) completed the same task while facing away from their co-actor. Unlike the experiment presented in the previous chapter, participants then completed two personality measures, one assessing their own personality and the other assessing their perceptions about their co-actor’s personality, in order to measure interpersonal projection (i.e., self–other overlap). They then completed measures assessing the degree to which they thought they had been synchronous and coordinated during the task and their sense of affiliation with their co-actor. In doing so, we investigated whether alignment influences affiliation via interpersonal projection (aka self–other merging) and/or via perceived (rather than objective) movement alignment.

We therefore measured the effect of synchrony (temporally and topologically aligned interpersonal movements), paired action (temporally aligned, topologically misaligned interpersonal movements), asynchrony (temporally misaligned, topologically aligned interpersonal movements), turn-taking (temporally and topologically matched movements, conducted during the co-actor’s rest period) and back-to-back movement (temporally and topologically matched movements, conducted while facing away from the co-actor) on affiliation (liking, rapport, similarity, IOS, and trust). We also examined the contributions of projection (as assessed by self-reported and perceived personality for self and co-actor) and interaction meta-judgments (perceived synchrony and perceived coordination) to determine which mechanism—interpersonal projection or interaction meta-judgments—mediates the affiliative effects of alignment.

Based on past research, we hypothesised that self-reported affiliation would be higher following synchronous than asynchronous movement and following turn-taking than a baseline condition. Based on our analysis regarding multisensory integration and common coding, we hypothesised that interpersonal projection would be stronger in the synchrony condition than all other conditions. We did not have clear predictions for the remaining comparisons for either self-reported affiliation or interpersonal projection.

2. Method

2.1 Participants and Design

Participants were 200 undergraduate psychology students (169 female; mean age = 19.83 years) at the University of Birmingham who completed the study in exchange for course credit. The experiment used a single-factor (Movement Condition: synchrony, paired action, asynchrony, turn-taking, B2B) between-participants design.

2.2 Apparatus

Questionnaires were administered on two Toshiba laptop computers (Toshiba, Tokyo), separated by a dividing screen (200 cm × 100 cm). In all other respects, apparatus matched that used for Experiment 1.

2.3 Stimuli

Stimuli were the same as for Experiment 1.

2.4 Procedure

The procedure was the same as in Experiment 1 except that participants completed their questionnaires in the same room. While making their responses participants were seated at either end of a table. Their view of the co-actor was occluded by a dividing screen.

2.4.1 Dependent measures. The measures were the same as Experiment 1, except that participants completed trait ratings and me/not-me judgements task in place of the joint Simon task.

2.4.1.1 Trait ratings. Participants completed two trait ratings measures: one in which they rated themselves, and one in which they rated their task partner. Target (self/other) order was randomized.

Stimuli consisted of 70 trait adjectives (35 from McCrae and Costa (1987) and 35 from Anderson (1968)), presented in random order. The McCrae and Costa (1987) stimuli corresponded to the five core personality traits identified in their five-factor model of personality (openness, conscientiousness, extroversion, agreeableness, neuroticism). Seven adjectives were selected per trait, approximately half of each having positive and half negative valence. The 35 adjectives drawn from Anderson (1968) consisted of neutral traits (i.e., that were normed as falling at, immediately above, or immediately below, the median-rated level of likeability. Care was taken to ensure that Anderson stimuli did not overlap in content/meaning with those taken from McCrea and Costa (1987). Hence, “solemn” and “dependent” were selected rather than “lonesome” and “conventional”, because “loner” and “conventional” were items drawn from the McCrae and Costa traits list.

For each item, participants rated the extent to which the trait could be ascribed to themselves or their partner on a 7-point scale from 0 (*definitely not one of my/my task partner's traits*) to 6 (*definitely one of my/my task partner's traits*).

2.4.1.2 Me/not-me judgement task. Next, participants completed a speeded reaction time task in which they judged whether a set of traits applied to them; the stimuli were the same traits used in the rating task. The instructions read:

> In this timed response questionnaire, a list of traits will be displayed. Please press the **A** key if you think the trait **IS,** and the **L** key if you think the trait is **NOT**, one of your own. Please ensure that each response is as **RAPID** as possible, as your responses will be timed. Remember: **A=ME, L=NOT ME**.

The caption, “Me=A, Not Me=L”, was displayed at the top of each display screen, and the target trait adjective was presented in bold letters (Times New Roman;

size = 18) beneath. Each stimulus was presented until a response was made, followed by a blank screen for 500 ms.

3. Results

Descriptive statistics are presented in Table 6. Unless otherwise indicated, all measures were analysed using single-factor (Movement Type: synchrony, paired action, asynchrony, turn-taking, B2B) ANOVAs.

Table 6

Self-Report Measure means [and 95% CIs] as a Function of Movement Condition, Experiment 2

	Synchrony (n = 40)	Paired Action (n = 40)	Asynchrony (n = 40)	Turn-Taking (n = 40)	Back-to-Back (n = 40)
Main measures					
Affiliation	3.70 [3.49, 3.91]	2.92 [2.71, 3.13]	2.94 [2.73, 3.15]	2.74 [2.53, 2.95]	2.57 [2.36, 2.77]
Perceived alignment	4.48 [4.04, 4.91]	2.80 [2.37, 3.24]	2.83 [2.39, 3.26]	3.16 [2.73, 3.60]	2.05 [1.62, 2.49]
Projection ratings	.16	.23	.16	.13	.20
Projection RTs	36.61 [-17.52, 90.74]	25.80 [-28.33, 79.93]	47.29 [-9.77, 104.35]	47.94 [-6.87, 102.76]	-2.07 [-56.88, 52.75]
Exploratory measures					
Task enjoyment	3.63 [3.26, 3.99]	3.88 [3.51, 4.24]	3.85 [3.48, 4.22]	3.43 [3.06, 3.79]	3.18 [2.81, 3.54]
Energy	2.98 [2.69, 3.26]	3.15 [2.87, 3.43]	3.20 [2.92, 3.48]	2.90 [2.62, 3.18]	3.00 [2.72, 3.28]
Self-awareness	4.45 [4.10, 4.80]	4.95 [4.60, 5. 30]	4.75 [4.40, 5.10]	4.63 [4.27, 4.98]	4.80 [4.45, 5.15]
Environment awareness	2.50 [2.06, 2.94]	2.43 [1.98, 2.87]	2.78 [2.33, 3.22]	2.08 [1.63, 2.52]	1.73 [1.28, 2.17]
Partner helpfulness	4.40 [3.95, 4.85]	1.28 [0.83, 1.72]	3.15 [2.70, 3.60]	3.18 [2.73, 3.62]	0.30 [-0.15, 0.75]
Partner distraction	2.50 [2.01, 2.99]	2.30 [1.81, 2.79]	2.90 [2.41, 3.39]	2.40 [1.91, 2.89]	0.75 [0.26, 1.24]
Mood	0.85 [0.55, 1.15]	0.65 [0.35, 0.95]	0.60 [0.30, 0.90]	0.55 [0.25, 0.85]	0.58 [0.28, 0.87]
Effort	5.73 [5.45, 6.00]	5.73 [5.45, 6.00]	5.60 [5.33, 5.88]	5.83 [5.55, 6.10]	5.68 [5.40, 5.95]

Note. Possible range = 0 to 6 for perceived alignment, affiliation, energy, awareness, task enjoyment, effort; -3 to +3 for mood, perceived helpfulness. Projection ratings = mean cross-correlations between self-ascribed and co-actor-ascribed traits. Projection RTs = $RT_{nonshared}$ – RT_{shared} (ms).

3.1 Self-Report Measures

3.1.1 Affiliation. To create an index of *affiliation*, we averaged across *IOS*, *liking*, *rapport*, *perceived similarity*, and *trust* items (Cronbach's $\alpha = .69$).

The ANOVA yielded an effect of movement condition, $F(4, 195) = 17.24$, $p < .001$, $\eta_p^2 = .261$. Participants reported more affiliation in three of the target conditions (synchrony, paired action, asynchrony) than in the B2B baseline condition (all $p < .02$), suggesting that both topological (synchrony, asynchrony) and temporal (synchrony, paired action) alignment promote affiliation. Affiliation ratings in the turn-taking condition did not differ from the B2B baseline ($p = .24$, $BF_{01} = 2.36$), paired action ($p = .20$, $BF_{01} = 2.06$), or asynchrony ($p = .17$, $BF_{01} = 1.90$) conditions, though Bayesian testing for these cases proved inconclusive (see Jarosz & Wiley, 2014).

Importantly, participants reported more affiliation in the synchrony condition than in the paired action and asynchrony conditions ($p < .001$). The contrast between the synchrony and asynchrony conditions corroborates previous findings on the relative advantage for synchrony over asynchrony. The contrast between the synchrony and paired action conditions suggests further that temporal alignment alone does not account for the beneficial effects of synchrony.

Affiliation ratings did not differ between the paired action and asynchrony conditions ($p > .88$), suggesting that temporal and topological overlap have equivalent effects. Moreover, Bayesian analysis revealed that affiliation levels in paired action and asynchrony were 4.26 times more likely to reflect the null effect (no group difference) than the alternative hypothesis.

3.1.2 Meta-judgment: Perceived alignment. The extent to which participants reported being in synchrony and coordinated with their task partner were averaged to create an index of perceived alignment (r = .68, p < .001).

A single-factor (Movement Type: synchrony, paired action, asynchrony, turn-taking) ANOVA yielded an effect of movement condition, $F(3, 156) = 13.38$, $p < .001$, $\eta_p^2 = .21$. Co-actors in the synchrony condition were regarded as more aligned than those in the paired action, asynchrony, and turn-taking (all p < .001) conditions. The perceived alignment of co-actors in the misaligned conditions did not differ from each other (paired action, asynchrony, turn-taking; all p > .25). Indeed Bayesian analysis revealed that perceived alignment ratings for paired action and asynchrony were 4.29 times more likely to reflect the null (no group difference) than the alternative hypothesis. As with affiliation, Bayesian analyses of the reported alignment of co-actors in the asynchrony (BF_{01} = 2.70) and paired action (BF_{01} = 2.47) conditions, against turn-taking, proved inconclusive. Hence, the pattern of effects obtained for perceived alignment mirrored that for affiliation[4].

3.1.3 Interpersonal projection.

3.1.3.1 Trait ratings. Fisher's r-to-z transformed values served as the measure of comparison. Cross-correlations between ratings for self-ascribed and co-actor-ascribed traits were calculated (mean r = .18, p = .01). Trait projection did not differ as a function of movement condition, $F(4, 195) = 0.62$, $p = .65$, $\eta_p^2 = .013$. Moreover, Bayesian analysis indicated that these differences were 23.74 times more likely to reflect a null effect (no group difference) than an effect of condition.

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[4] Participants in the B2B baseline completed the same measures assessing co-actor alignment as in other conditions. This data was collected to enable construction of the reference variable for mediation analysis only, and was therefore not included in other analyses involving perceived alignment, such as here.

3.1.3.2 Me/not-me judgments. For the me/not-me judgments task, traits were classified as “true” or “false” depending on where they had fallen relative to the median score on the (previous) trait ratings questionnaires (i.e., rated as true for respondent/co-actor: > 3; not rated as true for respondent/co-actor: < 3; scale range: 0–6). Latencies for shared versus non-shared traits in the me/not-me judgments task were therefore obtained by averaging across traits which were rated by the respondent as true/false for both themselves and their co-actor (i.e., TT, FF), or as true for either themselves only or their co-actor only (i.e., TF, FT; see Aron et al., 1991).

A 2 (Trait Overlap: shared, unshared) × 5 (Movement Type: synchrony, paired action, asynchrony, turn-taking, B2B) mixed-model ANOVA revealed no effect of movement condition, $F(4, 189) = 0.55$, $p = .70$, $\eta_p^2 = .011$. That is, response time differences to shared vs. non-shared traits were the same across groups. Furthermore, Bayesian analysis showed the effect of movement condition on shared vs. non-shared latencies was 28.26 times more likely to reflect the null (no group difference) than the alternative hypothesis.

3.1.4 Exploratory analyses. Several of the self-report items were included without specific a priori hypotheses.

3.1.4.1 Task enjoyment. Task enjoyment was influenced by movement condition, $F(4, 195) = 2.54$, $p = .04$, $\eta_p^2 = .05$. Participants in the asynchrony and paired action conditions reported higher task enjoyment than did participants in the B2B condition (both $p < .01$). No other comparisons were reliable (all $p > .07$).

3.1.4.2 Energy. Energy levels were not affected by movement condition, $F(4, 195) = 0.78$, $p = .54$, $\eta_p^2 = .016$.

3.1.4.3 Self- and environment-awareness. Self-awareness was not affected by movement condition, $F(4, 195) = 1.10$, $p = .36$, $\eta_p^2 = .022$. However, awareness of the environment was influenced by condition, $F(4, 195) = 1.10$, $p = .36$, $\eta_p^2 = .022$. Participants in all target conditions (synchrony, paired action, asynchrony) except turn-taking ($p = .29$) reported more environment awareness than participants in the B2B baseline (all $p < .03$). Asynchrony evoked more environment awareness than turn-taking ($p = .03$). No other comparisons were significant (all $p = .19$).

3.1.4.4 Perceived helpfulness. The perceived helpfulness of co-actors was affected by movement condition, $F(4, 195) = 52.64$, $p < .001$, $\eta_p^2 = .519$. Actors were perceived as more helpful in the synchrony condition (temporo-topological alignment) than in all other conditions (all $p < .01$). Actors in the turn-taking and asynchrony (both types of topological alignment) condition were perceived to be more helpful than those in the paired action (temporal alignment; $p < .001$) condition, though actors in turn-taking and asynchrony conditions were not perceived to differ ($p = .95$). Co-actors in all conditions were thought to be more helpful than in the B2B baseline ($p < .001$).

3.1.4.5 Perceived distraction. Co-actors in all movement conditions were perceived to be more distracting than co-actors in the B2B baseline condition (all $p < .001$), $F(4, 195) = 11.24$, $p < .001$, $\eta_p^2 = .187$. No other conditions differed (all $p > .08$).

3.1.4.6 Mood. Mood was not affected by movement condition, $F(4, 195) = 0.64$, $p = .64$, $\eta_p^2 = .01$.

3.1.4.7 Effort. The amount of reported effort required to complete the task was not affected by movement condition, $F(4, 195) = 0.35$, $p = .85$, $\eta_p^2 = .007$.

3.2 Kinematic Analysis

3.2.1 Digital video data. A set of digital data was corrupt and was therefore dropped from analysis. Inter-frame differences for 200 participants were successfully extracted, filtered to remove high frequency noise, and calculated using Ramsayer and Tschacter's (2008) Motion Energy Analysis (MEA) tool. This software subtracts user-identified regions of interest within each image frame from its associated region of interest in the subsequent frame. The standardised result is therefore a measure of the amount of change that occurs in each region of interest (ROI) over successive images.

Two ROIs—one corresponding to each co-actor—were identified within each digital recording. To ensure that the majority of inter-frame differences within each ROI corresponded to arm movements, rather than clothing or subtle postural adjustments, and given the explicit nature of the movements of interest, the threshold for change detection was set to 25 pixels rather than the default setting (15 pixels).

3.2.1.1 Sanity check: Individual means. Since stimuli were manipulated solely in terms of their alignment relative to the co-actor's stimuli (temporally, topologically), the stimuli and tempi presented to participants individually were the same across conditions. As a result, if participants were completing their assigned movements as intended, then analysis of digital measures of participants' movements should reveal no temporo-topological difference between conditions. Indeed, mean inter-frame change did not differ between movement condition, $F(4, 195) = 0.72$, $p = .58$, $\eta_p^2 = .01$, $BF_{01} = 48.53$.

3.2.1.2 Individual SDs. There was no evidence in digital recordings that participants' movement was destabilised by misalignment: Individuals' inter-frame change SD was not affected by movement condition, $F(4, 195) = 0.85$, $p = .50$, $\eta_p^2 = .02$, $BF_{01} = 15.42$.

3.2.1.3 Cross-correlations. Fisher's r-to-z transformed correlations of the inter-frame change in these separate ROIs served as the measure of comparison. Movement condition influenced the extent to which co-actors' inter-frame change

Table 7

Digital Video Measures [and 95% CIs] as a Function of Movement Condition, Experiment 2

	Synchrony (n = 40)	Paired Action (n = 40)	Asynchrony (n = 40)	Turn-Taking (n = 40)	Back-to-Back (n = 40)
Individual mean (px/frm-1)	218.56 [197.31, 239.81]a	240.21 [218.95, 261.46]a	236.60 [215.35, 257.86]a	236.86 [215.61, 258.11]a	25.57 [204.32, 246.82]a
Individual SD (px/frm-1)	276.43 [251.75, 301.12]a	285.27 [260.59, 309.96]a	289.30 [264.61, 313.98]a	259.80 [235.11, 284.49]a	282.35 [257.66, 307.04]a
Cross-correlation (lag 0 sec)	.84a	.75b	.74b	.07c	.77b

Note. Px/frm-1 = inter-frame pixel change. Dissimilar letter subscripts denote differences at $p < .05$.

rates corresponded, $F(4, 95) = 61.12$, $p < .001$, $\eta_p^2 = .720$. Synchrony evoked greater inter-frame correspondence than all other conditions (all $p < .02$). Asynchrony, paired action and B2B baseline did not differ (all $p > .32$). And all conditions, including B2B baseline, brought about more inter-frame change correspondence than turn-taking (all $p < .001$).

3.2.2 Inertial motion data. Velocity profiles for 198 out of the 200 recorded movement blocks—at least one block for all 200 participants—were successfully extracted and subjected to low pass Butterworth filter. The difference between successive observations were first calculated for the x, y and z dimensions independently. The square root of the sum of squares of the results were then combined across dimensions, forming a single non-directional array–speed. To assess the temporal similarity of co-actors' movements, co-actors' speed profiles were cross-correlated at a lag of 0 seconds (*speed cross-correlation*). To measure individuals' discrete contributions, each participant's mean speed (individual mean speed) and the standard deviation of their speed (individual SD speed) were quantified.

3.2.2.1 Sanity check: Individual means. As with mean inter-frame change, individual mean speeds were not influenced by movement condition, $F(4, 195) = 0.196$, $p = .94$, $\eta_p^2 = .004$, $BF_{01} = 49.23$.

3.2.2.2 Individual SDs. As with inter-frame SD, the standard deviations of participants' speeds were not affected by movement, $F(4, 195) = 0.69$, $p = .60$, $\eta_p^2 = .014$, $BF_{01} = 26.22$.

3.2.2.3 Cross-correlations. Fisher's r-to-z transformed correlations between participants' movement speeds were affected by movement condition, $F(4, 95) = 154.42$, $p < .001$, $\eta_p^2 = .867$ (see Table 8). Speed correspondence between co-actors was greater for synchrony than all other conditions (all $p < .02$). Speed correspondence did not differ between paired action, asynchrony, and B2B baseline (all p >.20), and was lower for turn-taking that all other conditions (all $p < .001$). Hence, the effects of condition on speed cross-correlations mirrored the effects of condition on inter-frame correlations (see above).

Table 8

Inertial Motion Measures [and 95% CIs] as a Function of Movement Condition, Experiment 2

	Synchrony (n = 40)	Paired Action (n = 40)	Asynchrony (n = 40)	Turn-Taking (n = 40)	Back-to-Back (n = 40)
Individual mean (m/s)	.022 [.020, .023]a	.021 [0.019, 0.022]a	.021 [0.020, 0.023]a	.021 [0.019, 0.023]a	.021 [0.20, 0.023]a
Individual SD (m/s)	.023 [0.021, 0.025]a	.021 [0.019, 0.023]a	.024 [0.021, 0.026]a	0.023 [0.021, 0.025]a	0.023 [0.020, 0.025]a
Cross-correlation (lag 0 sec)	.62a	.49b	.54b	-.33c	.54b

Note. Dissimilar letter subscripts denote differences at $p < .05$.

3.3 Mediation of synchrony–affiliation relationship. Inter-measure correlations are presented in Table 9. Examination of these correlations highlights that one of the two proposed mechanisms underpinning the alignment–affiliation relationship, perceived alignment, correlated reliably with participants' affiliation ratings. Neither measure of projection demonstrated a significant relationship with affiliation.

In conjunction with the fact that perceived alignment also varied as a function of movement condition in a manner similar to affiliation, we tested whether perceived alignment acts as a mediator of the synchrony–affiliation relationship. We tested a mediation model in which the association between movement type and affiliation is at least partly accounted for by perceived alignment. We tested this theoretical model via a regression model, using the SPSS PROCESS macro written by Hayes (2013; Preacher, Rucker, & Hayes, 2007); we conducted a bootstrapping analysis with 10,000 estimates for the construction of 95% bias-corrected confidence intervals for the indirect effects. Four of the five conditions were dummy coded, thereby allowing the fifth (B2B) to act as reference group (see Hayes & Preacher, 2014).

As Figure 3 shows, movement condition was related reliably to both affiliation, $F(4, 195) = 17.24$, $p < .001$, $R2 = .26$, and the proposed mediator, perceived alignment (Path *a*), $F(4, 195) = 16.18$, $p < .001$, $R2$ =. 25. Moreover, perceived alignment predicted affiliation levels, $F(5, 194) = 18.32$, $p < .001$, $R2 = .32$, partially accounting for the impact of movement condition on affiliation (see also Appendix B). In none of the regression analyses did the 95% confidence interval for the mediation effect of perceived alignment include zero, further substantiating the evidence for the effect of perceived alignment. Hence, perceived alignment mediated the effect of interpersonal movement on affiliation.

Table 9

Correlations between Dependent Measures, Experiment 2

		1	2	3	4	5	6	7	8	9	10	11	12
1	Affiliation	-											
2	Perceived alignment	.45**	-										
3	Projection: Ratings	.06	-.01	-									
4	Projection: RT	-.09	.00	.06	-								
5	Digital: Co-actor correlation	.20**	.16*	.08	.04	-							
6	Digital: Individual mean	-.05	-.15	.05	-.07	-.08	-						
7	Digital: Individual SD	.06	-.06	-.01	-.08	.03	.84**	-					
8	Digital: Co-actor SD	-.08	-.11	.05	.03	.03	.06	.03	-				
9	Inertial: Co-actor correlation	.17*	.12	.06	-.02	.79**	-.00	.16*	.16*	-			
10	Inertial: Individual mean	.06	.04	.08	-.03	.02	-.04	.06	.06	.06	-		
11	Inertial: Individual SD	.09	-.01	.10	-.03	-.04	-.07	.05	.06	.02	.96**	-	
12	Inertial: Co-actor SD	.11	-.09	.08	-.17*	-.04	-.04	.06	.05	.02	.26**	.35**	-

Note. “Inertial” and “Digital” refer to the dependent indirect measures of temporality (speed) and topology (no. of pixels to change between frames) respectively. * $p < .05$, ** $p < .01$.

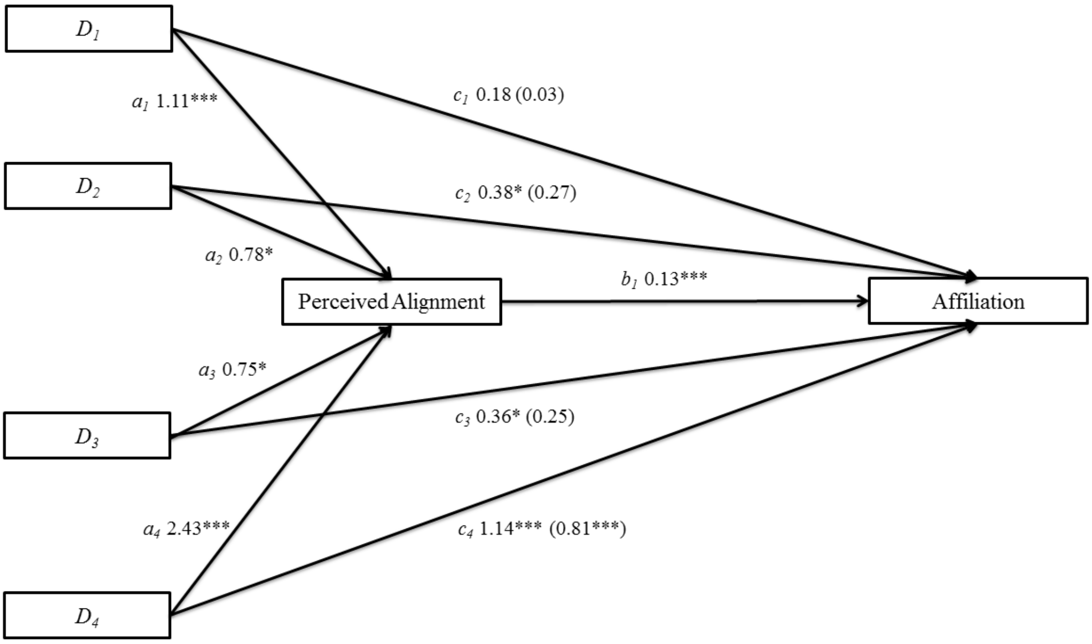

Figure 3. Model depicting the effects of interpersonal movement condition on affiliation, Experiment 2. Groups were categorized according to movement condition: Turn-Taking (D1), Paired Action (D2), Asynchrony (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Direct effect (c') presented in parentheses. *$p < .05$, **$p < .01$, *** $p < .001$.

Both objective measures of interpersonal alignment (inter-frame cross-correlation, speed cross-correlation) were also tested as a candidate mediator of the effect of condition on affiliation, given that they varied as a function of movement condition and correlated reliably with affiliation. Though inter-frame and speed cross-correlation were both related to movement condition (digital: $F(4, 195) = 316.97$, $p < .001$, $R2 = .87$; speed: $F(4, 195) = 125.45$, $p < .001$, $R2 = .72$), neither measure predicted affiliation in the mediation analysis (digital: $b = -0.06$, $p = .74$; speed: $b = -0.33$, $p = .29$; see Appendices C–D). Furthermore, in all of the regression analyses, the 95% confidence interval for the mediation effect included zero. Therefore, we found no evidence that either inter-frame cross-correlation or speed cross-correlation mediated affiliation.

4. Discussion

The present experiment examined the affiliative effects of temporal and topological alignment on affiliation. Dyads completed movements aligned on one (topological: asynchrony; temporal: paired action) or both (synchrony) dimensions before reporting their sense of affiliation with their co-actor; we also included a condition in which participants took turns making the same movements at the same tempo (turn-taking; somewhat akin to mimicry) and a movement-only control condition (B2B baseline).

4.1 Effects of Temporal and Topological Alignment on Affiliation

Our results revealed that the affiliation evoked by temporo-topological alignment (synchrony) was greater than the affiliative effects of either temporal (paired action) or topological (asynchrony) alignment alone. Hence, alignment on both dimensions elicits greater levels of affiliation than alignment on either dimension independently. In comparing the outcomes of temporal and topological alignment separately, however, we found no evidence for a prioritization of either form: Affiliation was statistically equivalent following paired action and asynchrony. Because no other research to date has compared the two forms of alignment, we had no empirical basis for expecting one to foster affiliation more than the other. Intuitively, we might have expected topological alignment to be more important than temporal alignment, given the greater physical differences between misaligned movements than misaligned timing (movements that differed along both horizontal and vertical bodily axes (see Figure 2) versus movement triplets that differed by less than one minute in time to completion). Nonetheless, differences in affiliation did not emerge between the paired action and asynchrony conditions.

We found that three of the target conditions (synchrony, paired action, asynchrony) all led to stronger affiliation relative to the B2B baseline. This contrasts with the non-effects of asynchrony and paired action on affiliation in the previous chapter. However, again, there was no evidence of a detrimental effect of misalignment: The affiliative effects of aligned movement were in fact greater than those obtained by the movements alone, even for those conditions in which misalignment was also present (temporal: asynchrony; topological: paired action). In sum, alignment on one dimension, even when misalignment was present on another, increased affiliation.

The evidence for affiliative effects of a single dimension of alignment was weaker, and often absent, when the comparison was the turn-taking condition. Self-reported affiliation in the turn-taking condition was in many cases statistically undifferentiable from self-reported affiliation in the paired action and asynchrony conditions, but also from self-reported affiliation in the B2B baseline. Although speculative, this pattern is nonetheless consistent with our argument that perceived alignment is critical to the affiliative effects of interpersonal movement. For our participants, seeing their co-actor engaged in the same movement, albeit at different times, may have given rise to a sense of shared experience, and this may have been sufficient to support a minimal sense of connectedness.

4.2 Mechanisms Accounting for the Alignment–Affiliation Relationship

4.2.1 Self–other overlap and meta-judgments of alignment. A key objective of the present experiment was to test self–other overlap (i.e., interpersonal projection) and meta-judgments about the movement task (i.e., perceived alignment) as potential mechanisms responsible for the affiliative effects of synchrony.

4.2.1.1 Self–other overlap. Participants completed a variety of measures including a self-report measure in which they rated their own personality and reported their beliefs about their co-actor's personality. They also completed a reaction-time measure that compared the speed with which they made judgments about their own personality traits; we examined response times for traits that they had indicated as having in common versus not with their co-actor in the self-report measure. Unlike affiliation, neither the self-report measure nor the reaction-time measure showed evidence of influence by movement condition. Acknowledging the challenge of interpreting the null (even in light of convincing Bayes factors in favour of the null), these findings do not support self–other merging as a mechanism implicated in the alignment–affiliation relationship.

These findings stand in contrast to those of Paladino and colleagues (2010), suggesting that self–other overlap from visuo-tactile alignment does not replicate with visuo-motor alignment. Paladino et al. (2010) found that the degree of projection was greater for synchronous than asynchronous visuo-tactile facial stimulation. There was no evidence in the current experiment that projection varied as a function of movement condition.

4.2.1.2 Meta-judgments. In this experiment, participants also rated the extent to which they thought they had been aligned with their co-actor during the interpersonal movement task. In this case, the reported levels of alignment during the interpersonal movement task were affected systematically by movement condition. As with affiliation, temporo-topological alignment brought about greater reported levels of alignment than any other condition; alignment on one dimension elicited the same levels of perceived alignment as alignment on the other dimension. Moreover, regression analysis supported our reasoning that the degree of perceived alignment during interpersonal movement would mediate the degree of affiliation evoked. Acknowledging that measurement-of-mediation designs are not as conclusive as experimental-causal-chain designs (Spencer, Zanna, & Fong, 2005), these findings nonetheless support our reasoning that meta-judgment is a mechanism in the alignment–affiliation relationship.

These results also dovetail with research in the field of joint action, much of which has explored the various mechanisms which enable joint action rather than focusing on its prosocial consequences (Vesper et al., 2016). In one such example (Vesper, van der Wel, Knoblich, & Sebanz, 2013), co-actors were required to jump forward while standing next to each other. Although participants were asked to land their jumps at the same time, their views of each other were occluded by a dividing screen; they were prevented from gaining online feedback about their partner’s behaviour during each trial. Instead they were presented with the distance that both they and their co-actor were required to jump at the start of each trial. Co-actors who were given the shorter jump distance delayed their movement onsets before initiating their jumps, thereby increasing the likelihood of aligning their landing times with their co-actor (Vesper, van der Wel, Knoblich, & Sebanz, 2013). Hence meta-judgments about alignment were essential to participants’ task strategies. We have shown that these meta-judgments may also influence the affiliative consequences of co-action.

4.2.2 Actual alignment. In developing our reasoning, we asserted that top-down processes (i.e., meta-judgments of alignment) were more likely to account for the alignment–affiliation relationship than were bottom-up processes (i.e., self–other integration as a result of actual alignment). Our lack of evidence for the role of self–other overlap, as indexed by interpersonal projection, seemed to support this assertion.

However, in the present experiment, we also measured actual alignment, giving us a second opportunity to explore the role of bottom-up processes. Interestingly, both measures of actual alignment showed the same influence of manipulated movement condition: Cross-correlations between co-actors' movement were higher in the fully aligned synchrony condition than in the partially aligned paired action and asynchrony conditions and the unaligned B2B baseline condition. Moreover, both measures also correlated positively with affiliation.

In light of these patterns, we considered actual alignment as a potential mediator between movement condition and self-reported affiliation; however, we did not observe statistical mediation of the movement–affiliation relationship by actual alignment. Acknowledging that measurement-of-mediation designs are not as conclusive as experimental-causal-chain designs (Spencer, Zanna, & Fong, 2005) and thus that future research might provide evidence for actual alignment as a mediator of the synchrony–affiliation relationship, the positive correlation between actual alignment and affiliation nonetheless suggests that bottom-up processes do contribute to the affiliative effects of synchrony. Considered through this lens, further exploration of bottom-up processes involved in the mediation of the alignment–affiliation relationship are warranted.

4.3 Misalignment versus Nonalignment

In the current experiment, movements that were aligned on one dimension and misaligned on another (temporally aligned, topologically misaligned: paired action; topologically aligned, temporally misaligned: asynchrony) evoked greater affiliation than baseline. Turn-taking, however, did not. Given that turn-taking involves one dimension of alignment (topological), this seems inconsistent with the affiliative effects of asynchrony and paired action. However, whereas asynchrony and paired action were characterised by one dimension of alignment and one dimension of misalignment, turn-taking was characterised by one dimension of alignment and one dimension that would be better labelled as *non*aligned rather than *mis*aligned. Because co-actor movements during turn-taking never overlapped in time, it is possible that participants in the turn-taking condition did not perceive the movement task as shared or interpersonal in nature.

4.4 Conclusion

In this experiment, participants in the synchrony condition reported more affiliation than in all other conditions. Judgments about alignment, but not perceptions about self–other similarity, mirrored the affiliation changes evoked by movement condition. For example, paired action and asynchrony led to equal increases in affiliation relative to B2B baseline, and contributed equally to perceptions of alignment. In contrast, interpersonal projection was not affected by condition. Judgements about alignment, and not interpersonal projection, mediated the relationship between movement condition and affiliation. In contrast, we found no evidence that our objective measures of alignment (inter-frame cross-correlation, speed cross-correlation) mediated outcome. This experiment has therefore uncovered early support for the idea that meta-judgments about relative task performance, rather than task performance itself, mediate the affiliative effects of co-action.

CHAPTER 4: INTERPERSONAL PROJECTION VERSUS PERCEIVED ALIGNMENT AS CANDIDATE MEDIATORS OF THE AFFILIATIVE EFFECTS OF *MIS*ALIGNMENT

The experiment presented in the current chapter examined the affiliative effects of interpersonal misalignment, again testing interpersonal projection and perceived alignment as potential mediators. Using a similar interpersonal movement paradigm and in Experiment 1–2, Experiment 3 introduced several different types of misalignment. Participants (N = 152; 76 dyads) were assigned to novel movement conditions that were designed to elicit synchrony (temporally and topologically aligned), paired asynchrony (temporally misaligned, topologically misaligned), delayed action (turn-taking with tempo matching, and topologically misaligned), or total misalignment (turn-taking with tempo mismatch, and topologically misaligned). Control participants made matched movements while facing away from their co-actor (back-to-back baseline). Participants completed measures assessing their perceptions of their own and their partner's personality (to index interpersonal projection) and the degree to which they perceived themselves as aligned with their partner. Perceived alignment, but not interpersonal projection, mediated the relationship between movement condition and affiliation, providing a conceptual replication of the high-order meta-judgments effect on affiliation found in the previous experiment. Misalignment did not influence affiliation, suggesting that alignment alone, rather than the absence of misalignment, is responsible for affiliative outcomes.

1. Introduction

In the previous experiment, alignment on both dimensions (temporal, topological; synchrony) evoked greater levels of affiliation than alignment on one dimension only (temporal: paired action; topological: asynchrony, turn-taking), but even alignment on one dimension (in combination with misalignment on another) evoked greater affiliation than baseline. Moreover, the perceived alignment of the co-actors' interpersonal movements was affected by movement condition, correlated with affiliation, and statistically mediated the affiliative outcomes of alignment. However, although alignment on both dimensions synchrony) led to greater levels of affiliation than alignment on one dimension only (paired action, asynchrony), Experiment 2 did not include in which both dimensions were misaligned. This is important because the nature of this moderate degree of pro-affiliative impact in the paired action and asynchrony conditions is unclear: Does synchrony evoked greater affiliation than paired action and asynchrony simply because there is "more" alignment, or does the misalignment in the paired action and asynchrony conditions undermine the affiliative effects of alignment? The goal of the final experiment was to explore this question.

This experiment used a similar experimental protocol to that used in the previous chapter, except that the affiliative effects of temporo-topological alignment (synchrony) were tested against interpersonal movements characterised by temporal and topological misalignment, and which were conducted concurrently (i.e., misalignment during movement execution) or non-concurrently (i.e., misalignment at the movement execution–rest interval level).

1.1 Misalignment and Affiliation

Affiliation seems to increase as a function of alignment. Comparisons in experiments presented previously, between synchrony, asynchrony, paired action, and turn-taking, indicated that affiliation is greater were alignment is present across dimensions (temporo-topological: synchrony) than present on only one (e.g., paired action, asynchrony). Yet this research focused exclusively on comparisons between synchrony and conditions that were comprised of alignment on at least one dimension (topological: asynchrony, turn-taking; temporal: paired action, turn-taking). Therefore, the role that misalignment plays remains somewhat unexplored, leading to difficulties interpreting the effect of movement structure on affiliation. For example, for paired action and asynchrony, which led to moderate increases in affiliation relative to B2B baseline, misalignment on one dimension (e.g., paired action: topological; asynchrony: temporal) may have counteracted the affiliative effects of alignment on the other (asynchrony: topological; paired action: temporal). This may have been responsible for the fact that these conditions evoked lower levels of alignment than that brought about by synchrony, which involved no misalignment. Alternatively, alignment alone may be responsible for the elevated levels of affiliation in these conditions relative to B2B baseline, and the fact that alignment was present on only one dimension was the reason why these levels elicited smaller increases in affiliation than synchrony, for which alignment was present on two dimensions. Therefore, in the present experiment, a condition was included that, unlike asynchrony and paired action, consisted of misalignment on both dimensions (i.e., temporal and topological misalignment; paired asynchrony). This condition allowed us to compare the effects of temporal and topological alignment with temporal and topological misalignment, thereby testing whether misalignment has a deleterious impact on affiliation.

The affiliative effects of undertaking movements at the same time as the co-actor (i.e., concurrent movement) is also unclear. In the previous experiment turn-taking did not increase affiliation relative to B2B baseline, unlike the two partially misaligned concurrent movements (paired action and asynchrony). Perhaps the reason why these partially misaligned interpersonal movement types increased affiliation was because they involved concurrent movement. If these conditions increased affiliation simply because they consisted of movements that co-occurred alongside the co-actor's, then movements which are misaligned across dimensions (i.e., temporally and topologically) but take place concurrently should evoke affiliative increases, too. Again, the inclusion of the paired asynchrony condition (temporal and topological misalignment) allowed us to test this in the present experiment.

The effects of misalignment in general are under-researched. Indeed, to our knowledge, there has been no research comparing the affiliative effects of different types of misalignment. Our findings reported for the previous chapter did not reveal differences between affiliation levels evoked by turn-taking and asynchrony. Yet the nature of temporal misalignment in each case was different. Asynchrony consisted of movements that were temporally misaligned (i.e., set to different tempi), nonetheless, they were concurrently conducted—co-actors' interpersonal movements took place at the same time. In contrast, turn-taking consisted of matched interpersonal movements that were set to the same tempi but took place during the co-actor's rest periods (i.e., non-concurrent). We have so far treated non-concurrent movements as on a spectrum with asynchrony and paired action, but turn-taking did not evoke positive affiliative change, in spite of the fact that asynchrony and paired action both evoked affiliation increases. As stated previously, this condition was intended to act as an analogue for mimicry. But mimicry commonly involves discrete, non-repetitive movements (see

Chartrand & Van Baaren, 2009). And so, the affiliative effects of mimicry may rely on other mechanisms than those which underpin the affiliative effects of synchrony. Nonetheless, including non-concurrent movement conditions enables investigation into the effects of concurrency, and the role that this plays in bringing about the affiliative effects of synchrony.

To further examine the effects of misalignment, interpersonal movements in the present experiment consisted of movements that were temporally and topologically aligned (synchrony); temporally and topologically misaligned (paired asynchrony); topologically misaligned but set to the same tempi (temporally aligned) and undertaken during the co-actor's rest periods (non-concurrent); or temporally and topologically misaligned, and took place during the co-actor's rest periods (non-concurrent; total misalignment; see Table 10).

Table 10
Additional Interpersonal Movement Types Characterised in Terms of Temporal and Topological Alignment

	Description	Temporal alignment	Topological Alignment
Paired Asynchrony	Co-actors conduct different movements at different tempi, at the same time	No	No
Delayed Action	Co-actors conduct different movements at the same tempi, and with movement onset temporally offset	Partially (tempi matched; non-concurrent)	No
Total Misalignment	Co-actors conduct different movements at different tempi, and with movement onset temporally offset	No (tempi mismatched; non-concurrent)	No

1.2 Modelling the Outcomes of Misalignment

Three competing mediator models would be predicted by divergent affiliative outcomes for the above conditions.

1.2.1 Motor interference. One means by which misalignment might feasibly reduce affiliation concerns visuo-motor interference. During co-action, motor representations responsible for encoding an actor's own movements and representations encoding a co-actor's observed movements are activated (see Chapter 2). So, where representations for self-generated movements share resources with those encoding for the co-actors' movements, interference may arise (see Logie, 1995). There is precedence for this reasoning in the literature: In one experiment, for example, participants were required to perform either horizontal or vertical arm movements (Kilner, Paulignan, & Blakemore, 2003). While doing so they observed a co-actor making congruent (same plane) or incongruent (orthogonal plane) movements. When the co-actor performed incongruent arm movements, participants' own movements were characterised by increased motor variability in the orthogonal plane. For example, observing the co-actor performing vertical arm movements while themselves making horizontal arm movements increased the vertical variability of their movements. Hence, observing incongruent actions led to motor interference (cf. Richardson, Campbell, & Schmidt, 2009).

This visuo-motor interference might be responsible for affiliative effects following misalignment. If a co-actor's movements evoke greater interference, and interference reduces affiliation, then more interfering movements should result in less affiliation. As a result, performing arm movements while observing a co-actor performing temporally and topologically misaligned arm movements (paired asynchrony) ought to have a more deleterious impact on affiliation than if co-actors' arm movements are temporally and topologically misaligned but occur during the observers rest periods (total misalignment). Hence, this interference-based mechanism would predict that misaligned movements which are concurrently conducted, such as paired asynchrony, should be more deleterious to affiliation than non-concurrent movements. This would be predicted irrespective of whether the non-concurrent movements are similar and matched in terms of tempo (e.g., turn taking) or are not (e.g., total misalignment). By measuring affiliation as a function of misalignment the present investigation tested whether interference can account for the effects of misalignment.

1.2.2 Perceived misalignment. In the previous chapter, we reported that the perceived alignment of co-actors' movements statistically mediated the affiliative outcomes of interpersonal movement. However, if the perceived *mis*alignment rather than the perceived alignment of the co-actor's movements influence the affiliative outcome during misalignment, then the pattern of effects would also be different than expected for an interference-based mechanism such as visuo-motor interference (described above). That is, if movements are valued negatively as a function of their misalignment rather than positively as a function of their alignment, then non-concurrently enacted movements (e.g., delayed action, total misalignment) would be perceived to be more misaligned than concurrent movements (e.g., paired asynchrony). As a result, non-concurrent movements should be expected to reduce affiliation levels relative to B2B baseline more so than concurrent interpersonal movements. Therefore, in contrast to an interference-based mechanism, if perceived misalignment evokes deleterious effects and counteracts the positive affiliative effects of alignment then non-concurrent movements should be more detrimental to affiliation than temporally misaligned concurrent movements.

1.2.3 Perceived alignment. A perceived alignment mechanism differs markedly in terms of our predictions concerning affiliation levels evoked. If perceived alignment rather than perceived misalignment mediates affiliation, then conditions that are characterised by misalignment across dimensions (e.g., paired asynchrony, total misalignment) should not affect affiliation levels. In other words, if perceived alignment mediates outcome, and interpersonal movements consist of a lack of alignment, no mediation and hence no effect on affiliation should occur. Therefore, unlike Chapter 3, where partially aligned conditions (paired action; asynchrony) increased affiliation levels relative to B2B baseline, if misalignment is present across dimensions (e.g., paired asynchrony, total misalignment), then interpersonal movement should not affect affiliation levels, either by increasing or decreasing them.

1.3 Overview of Research

By manipulating the nature of misalignment during interpersonal movement, the current experiment investigated whether the mechanisms responsible for the affiliative consequences of interpersonal alignment also mediate the affiliative effects arising from interpersonal misalignment.

To explore these possible effects, we measured the effect of synchrony (temporally and topologically aligned movements), paired asynchrony (temporally misaligned, topologically misaligned movements), delayed action (turn-taking with temporally matching and topologically misaligned movements), and total misalignment (turn-taking with temporally mismatching, and topologically misaligned movements). Control participants made matched movements while facing away from their co-actor (back-to-back baseline). Participants completed the same measures used in the previous experiment to assess their perceptions of their own and their partner's personality (to index self–other similarity) and the degree to which they perceived themselves as aligned with their partner, ensuring that the experiment was similar except for the interpersonal movements themselves.

Based on past research and the results of the foregoing experiments, we hypothesised that self-reported affiliation would be higher following synchronous movement than all other forms of movement. Regarding the outcomes of different forms of misalignment, different outcomes would be expected given different intermediary mechanisms. If motor interference elicits affiliative reductions as a function of misalignment, interpersonal movements which are both concurrent and misaligned would have a more deleterious impact on affiliation than those which are misaligned but non-concurrent (i.e., made during the co-actor's rest periods). This would be expected because non-concurrent movements would be expected to evoke less interference, given that because they do not co-occur they would not compete for neural resources (Logie, 1995). In contrast, if co-actors' judgments about the level of misalignment mediate outcome the converse would be true—interpersonal movements which are misaligned but non-concurrent (e.g., total misalignment) would have a more deleterious impact on affiliation than those which are concurrent and misaligned (paired asynchrony). This is expected because when participants perform movements while the co-actor is not moving they are more misalignment. Lastly, if as in the previous experiment, perceived alignment rather than misalignment or interference is responsible for outcome, then no differences should be detected across misalignment conditions.

We did not make predictions regarding interpersonal projection, based on the lack of evidence for effects in Experiment 2; we were simply interested in whether the null effect observed in Experiment 2 would replicate.

2. Method

2.1 Participants and Design

Participants were 152 undergraduate psychology students (137 female; mean age = 19.26 years) at the University of Birmingham who completed the study in exchange for course credit. One participant's self-report data were removed at her own request. The experiment used a single-factor (Movement Condition: synchrony, paired asynchrony, delayed action, total misalignment, B2B) between-participants design.

2.2 Apparatus

Apparatus was the same as that used for Experiment 2.

2.3 Stimuli

Movement stimuli for the synchrony and B2B baseline conditions were the same as those used in Experiment 2 (see Figure 4). Condition-specific stimuli for the novel conditions in this experiment (paired asynchrony, delayed action, total misalignment) were constructed by aligning and "panning" stimulus strings separately to either the left or right headset, as depicted in Figure 4.

2.3.1 Paired asynchrony. Stimuli and ISIs were misaligned. As a result, stimulus triplet onsets were also misaligned (i.e., resultant stereo files were produced from the following mono files: Seq1fast × Seq2slow, Seq1slow × Seq2fast, Seq2fast × Seq1slow, Seq2slow × Seq1fast). To enable stimulus mismatch, stimulus strings were duplicated. Rest periods were increased to 4800 ms for half of the fast duplicates (S1fastincr, S1fast, S2fastincr, S2fast), and decreased to 2100 ms for half of the slow duplicates (S1slowdecr, S1slow, S2slowdecr, S2slow). To maximise temporal misalignment between stimuli, the onset for slow strings was subjected to a 150 ms delay (S1fastincr × S2slow, S1fast × S2slowdecr, S2slowdecr × S1fast, S2slow ×

S1fastincr, S2fastincr × S1slow, S2fast × S1slowdecr, S1slowdecr × S2fast, S1slow × S2fastincr). In other words, co-actors made different movements, at different tempi, with overlapping movement onset.

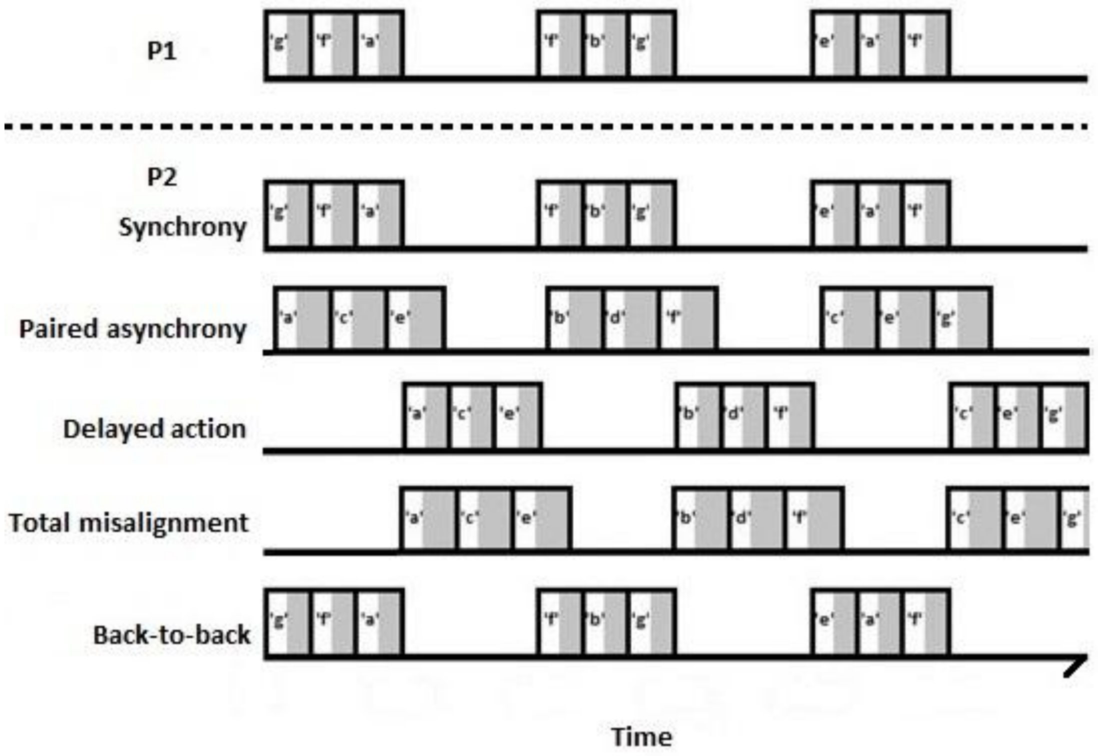

Figure 4. Schematic portraying temporal relationships between the audio stimuli presented to each participant (participant one: P1; participant two: P2) for each condition, Experiment 3. *Note.* Grey areas denote silent periods within stimulus triplets.

2.3.2 Delayed action. The stimuli were similar to those used in turn-taking condition in that the onsets of stimulus triplets in one string were aligned with the rest period onsets in the other. Unlike the turn-taking condition, however, stimuli were topologically misaligned (resultant stereo files produced from the following mono files: Seq1fast × Seq2fast, Seq1slow × Seq2slow, Seq2fast × Seq1fast, Seq2slow × Seq1slow). In other words, co-actors made different movements, at the same tempi, with no movement timing overlap.

2.3.3 Total misalignment. The stimuli were the same as for delayed action except the ISIs were also misaligned (resultant stereo files produced from the following mono files: Seq1fast × Seq2slow, Seq1slow × Seq2fast, Seq2fast × Seq1slow, Seq2slow × Seq1fast). Stimulus strings were duplicated. Rest periods were increased to 4800 ms for half of the fast duplicates (S1fastincr, S1fast, S2fastincr, S2fast), and decreased to 2100 ms for half of the slow duplicates (S1slowdecr, S1slow, S2slowdecr, S2slow). To maximise temporal misalignment between stimuli, the onset for slow strings was subjected to a 150 ms delay (S1fastincr × S2slow, S1fast × S2slowdecr, S2slowdecr × S1fast, S2slow × S1fastincr, S2fastincr × S1slow, S2fast × S1slowdecr, S1slowdecr × S2fast, S1slow × S2fastincr). In other words, co-actors made different movements, at different tempi; their rest intervals also differed, leading to movement onset misalignment.

2.4 Procedure

The procedure and measures were the same as in Experiment 2.

3. Results

Descriptive statistics are presented in Table 11. Unless otherwise indicated, all measures were analysed using single-factor (Movement Type: synchrony, paired asynchrony, delayed action, total misalignment, B2B) ANOVAs.

3.1 Self-Report Measures

3.1.1 Affiliation. As in Experiments 1 and 2, to create an index of *affiliation*, we averaged across *IOS*, *liking*, *rapport*, *perceived similarity*, and *trust* items (Cronbach's $\alpha = .77$). The ANOVA yielded an effect of movement condition, $F(4, 146) = 2.65$, $p = .04$, $\eta_p^2 = .068$. Participants reported more affiliation in synchrony than in all other conditions ($p < .04$), except delayed action ($p = .12$). However, Bayesian analysis suggested that the affiliation levels reported following synchrony and delayed action

Table 11

Self-Report Measure Means [and 95% CIs] as a Function of Movement Condition, Experiment 3

	Synchrony (n = 30)	Paired Asynchrony (n = 30)	Delayed Action (n = 32)	Total Misalignment (n = 29)	Back-to-Back (n = 30)
Main measures					
Affiliation	3.43 [3.10, 3.75]	2.91 [2.58, 3.23]	3.04 [2.72, 3.35]	2.86 [2.53, 3.19]	2.73 [2.40, 3.05]
Perceived alignment	4.18 [3.69, 4.68]	1.67 [1.17, 2.16]	1.72 [1.24, 2.20]	1.83 [1.32, 2.33]	2.12 [1.62, 2.61]
Projection ratings	.21	.16	.15	.09	.15
Projection RTs	28.70 [-20.04, 77.44]	34.24 [-16.21, 84.69]	12.42 [-34.77, 59.62]	-12.24 [-62.69, 38.21]	23.31 [-25.43, 72.05]
Exploratory measures					
Task enjoyment	3.97 [3.57, 4.36]	3.13 [2.74, 3.53]	3.56 [3.18, 3.95]	3.69 [3.29, 4.09]	3.40 [3.00, 3.80]
Energy	3.33 [3.00, 3.66]	2.80 [2.47, 3.13]	2.88 [2.56, 3.19]	3.17 [2.84, 3.51]	2.80 [2.47, 3.13]
Self-awareness	4.63 [4.17, 5.09]	4.80 [4.34, 5.26]	4.34 [3.90, 4.79]	4.48 [4.02, 4.95]	4.20 [3.74, 4.66]
Environment awareness	2.43 [1.92, 2.95]	2.63 [2.12, 3.15]	2.84[2.35, 3.34]	2.48 [1.96, 3.00]	1.70 [1.19, 2.21]
Partner helpfulness	3.87 [3.44, 4.29]	1.20 [0.78, 1.62]	0.78 [0.37, 1.19]	1.10 [0.67, 1.54]	0.53 [0.11, 0.96]
Partner distraction	3.33 [2.79, 3.87]	3.27 [2.73, 3.81]	2.59 [2.07, 3.12]	2.83 [2.28, 3.38]	0.43 [-0.11, 0.97]
Mood	0.73 [0.44, 1.02]	0.33 [0.04, 0.62]	0.41 [0.13, 0.69]	0.31 [0.02, 0.60]	0.40 [0.11, 0.69]
Effort	6.17 [5.82, 6.52]	5.87 [5.52, 6.22]	5.53 [5.19, 5.87]	5.59 [5.23, 5.94]	5.60 [5.25, 5.95]

Note. Possible range = 0 to 6 for perceived alignment, affiliation, energy, awareness, task enjoyment, effort; -3 to +3 for mood, perceived helpfulness. Projection ratings = *r* to *z* transformed cross-correlations between self-ascribed and co-actor-ascribed traits. Projection RTs = $RT_{nonshared} – RT_{shared}$ (ms).

were insufficient to support either the null (no difference) or the alternative hypothesis (BF_{01} = 1.33). No other comparisons, including against B2B baseline, differed (p > .11).

In terms of the target conditions, Bayesian analysis provided tentative evidence that there were no differences between misalignment conditions (total misalignment versus paired asynchrony, BF_{01} = 3.77; paired asynchrony versus delayed action, BF_{01} = 3.38; total misalignment versus delayed action, BF_{01} = 2.97).

In terms of comparisons with the baseline, Bayesian analysis provided tentative evidence that total misalignment did not differ from B2B baseline (BF_{01} = 3.20). Bayesian analysis of paired asynchrony and delayed action versus B2B were inconclusive (BF_{01} = 2.91 and 1.74, respectively). Affiliation was not therefore *reduced* by misalignment.

In contrast to the non-effect of total misalignment, alignment on both dimensions (temporo-topological alignment; synchrony) increased affiliation relative to B2B baseline. This positive effect of temporo-topological alignment on affiliation replicates the positive effect of the same effect found in Experiments 1–2, and further substantiates the positive effects of synchrony reported elsewhere. Though the (non)effect of total misalignment relative to B2B baseline has not, to our knowledge, been examined in the literature, this effect is also consistent with the impact of misalignment reported for Experiments 1–2.

3.1.2 Meta-judgment: Perceived alignment. As with Experiments 1–2, the extent to which participants reported being in synchrony and coordinated with their task partner were averaged to create an index of perceived alignment (r = .74).

A single-factor (Movement Type: synchrony, paired asynchrony, delayed action, total misalignment) ANOVA yielded an effect of movement condition, $F(3, 117) = 23. 97$, $p < .001$, $\eta_p^2 = .38$.

Follow-up comparisons revealed that participants in the synchrony condition perceived greater alignment than those in all other conditions (all $p < .001$). The perceived alignment of co-actors in misalignment conditions (paired asynchrony, delayed action, total misalignment) did not differ from each other (all $p > .68$). Bayesian analysis tentatively supported this non-effect. The perceived alignment of co-actors in the misalignment conditions (paired asynchrony, delayed action, total misalignment) was more likely to reflect the null hypothesis than the alternative hypothesis (all $BF_{01} > 3.51$).

In other words, co-actors who were aligned on both dimensions (temporo-topological; synchrony) were perceived to have been more aligned than co-actors in the misalignment conditions, irrespective of the nature of misalignment present. In contrast, co-actors whose movements were misaligned in any way were not perceived as differentially (mis)aligned: Ratings of perceived alignment did not differ between the paired asynchrony condition (concurrent, temporo-topological misalignment), the delayed action condition (non-concurrent, temporal alignment and topological misalignment), or even the total misalignment condition (non-concurrent, temporo-topological misalignment). Hence, the type of misalignment present did not impact on participants' judgements.

These findings are consistent with those found for affiliation (see above). Just as temporo-topological alignment (synchrony) increased affiliation levels relative to all types misalignment (paired asynchrony, delayed action, total misalignment), the movements of co-actors undertaking temporo-topological alignment (synchrony) were reported as more aligned than those in all misalignment conditions. Additionally, just as there was no evidence that different types of misalignment differentially affected affiliation, co-actors undertaking different types of misalignment were perceived to be equally aligned.

3.1.3 Interpersonal projection.

3.1.3.1 Trait ratings. Cross-correlations between ratings for self-ascribed and co-actor-ascribed traits were calculated (r = .15, p = .07) and their r-to-z transformed values served as the measure of comparison. Trait projection did not differ as a function of movement condition, $F(4, 146) = 0.62$, $p = .65$, $\eta_p^2 = .017$. Furthermore, Bayesian analysis indicated that these self-other trait ratings were 18.53 times more likely to reflect the null (no group difference) than the alternative hypothesis.

3.1.3.2 Me/not-me judgments. A 2 (Trait Overlap: shared, unshared) × 5 (Movement Type: synchrony, paired asynchrony, delayed action, total misalignment, B2B) mixed-model ANOVA revealed that latencies for shared versus non-shared traits in the me/not-me judgments task were not affected by movement condition, $F(4, 143) = 0.52$, $p = .72$, $\eta_p^2 = .014$. That is, response time differences to shared vs. non-shared traits were the same across groups. Bayesian analysis indicated that the effect of movement condition on shared vs. non-shared latencies was 20.81 times more likely to reflect the null (no group difference) than the alternative hypothesis.

In summary, neither measure of interpersonal projection (trait ratings and me/not-me judgment times) was affected by movement condition as self-reported affiliation, and perceived alignment levels had been.

3.1.4 Exploratory analyses. The same items that were included in Experiment 2 without specific *a priori* hypotheses were also included as exploratory items in the present experiment.

3.1.4.1 Task enjoyment. Task enjoyment differed as a function of movement condition, $F(4, 146) = 2.42$, $p = .05$, $\eta_p^2 = .062$. Synchrony was more enjoyable than paired asynchrony and B2B baseline (both $p < .04$). No other comparisons differed (all $p > .09$).

3.1.4.2 Energy. Energy levels were not affect by movement condition, $F(4, 146) = 2.12$, $p = .08$, $\eta_p^2 = .055$.

3.1.4.3 Self- and environment-awareness. Self-awareness did not differ as a function of movement condition, $F(4, 146) = 1.03$, $p = .39$, $\eta_p^2 = .028$. Awareness of the environment was influenced by movement condition, F(4, 146) = 2.83, $p = .03$, $\eta_p^2 = .072$. Participants reported having been more aware of their environment in all conditions than in the B2B baseline ($p < .04$) (all other $p > .09$).

3.1.4.4 Perceived helpfulness. The perceived helpfulness of co-actors differed as a function of movement condition, $F(4, 146) = 39.75$, $p < .001$, $\eta_p^2 = .521$. Synchronous co-actors were reported to have been more helpful than in all other conditions ($p < .001$). Co-actors in the paired asynchrony condition were reported to have been more helpful than in the B2B baseline ($p = .02$). A trend to significance was reported for participants in the total misalignment and B2B baseline condition ($p = .05$). No other comparisons differed (all $p > .19$).

3.1.4.5 Perceived distraction. Co-actors in all movement conditions were described as more distracting than those in B2B baseline (all $p < .001$), $F(4, 146) = 18.93$, $p < .001$, $\eta_p^2 = .342$ (all other $p > .06$).

3.1.4.6 Mood. Mood was not affected by movement condition, $F(4, 146) = 1.36$, $p = .25$, $\eta_p^2 = .036$.

3.1.4.7 Effort. The amount of reported effort required to complete the task was not influenced by movement condition, $F(4, 146) = 2.31$, $p = .06$, $\eta_p^2 = .060$.

3.2 Kinematic Analysis

3.2.1 Digital video data. One set of digital data, corresponding to one movement block, was corrupted during recording and was therefore dropped from analysis. Inter-frame differences for all 152 participants were successfully extracted, filtered to remove high frequency noise, and calculated using Ramsayer and Tschacter's (2008) Motion Energy Analysis (MEA) tool. As in Experiments 1–2, two ROIs—one corresponding to each co-actor—were identified within each digital recording, and the threshold for change detection was set to 25 pixels.

3.2.1.1 Individual means. Individuals' mean inter-frame change did not differ between movement conditions, $F(4, 147) = 1.28$, $p = .28$, $\eta_p^2 = .03$, $BF_{01} = 7.19$.

3.2.1.2 Individual SDs. The standard deviation of the inter-frame change did not differ between movement conditions, $F(4, 147) = 1.67$, $p = .16$, $\eta_p^2 = .04$, $BF_{01} = 4.01$.

3.2.1.3 Cross-correlations. Movement condition influenced the extent to which co-actors' inter-frame differences corresponded, $F(4, 71) = 60.13$, $p < .001$, $\eta_p^2 = .772$. Synchrony led to greater inter-frame cross correlation than all other conditions ($p < .02$). Inter-frame correlation was greater for B2B baseline than all other conditions ($p < .001$) except paired asynchrony ($p = .28$); while paired asynchrony was more aligned than delayed action and total misalignment (both $p < .001$). Delayed action and total misalignment did not differ ($p = .88$).

3.2.2 Inertial motion data. Velocity profiles for all of the recorded movement blocks—for all 152 participants—were successfully extracted and subjected to low pass Butterworth filter.

3.2.2.1 Individual means. Individuals' mean speeds were not influenced by movement condition, $F(4, 147) = 1.22$, $p = .31$, $\eta_p^2 = .03$, $BF_{01} = 7.87$.

Table 12

Digital Video Measures [and 95% CIs] as a Function of Movement Condition, Experiment 3

	Synchrony (n = 30)	Paired Asynchrony (n = 30)	Delayed Action (n = 32)	Total Misalignment (n = 29)	Back-to-Back (n = 30)
Individual mean (px/frm-1)	224.97 [191.44, 258.50]a	234.22 [200.69, 267.75]a	229.03 [196.56, 261.49]a	246.33 [212.80, 279.86]a	272.40 [238.88, 305.93]a
Individual SD (px/frm-1)	277.37 [239.68, 315.06]a	271.31 [233.62, 309.00]a	235.28 [198.79, 271.77]a	249.86 [212.18, 287.55]a	297.72 [260.03, 335.41]a
Cross-correlation (lag 0 sec)	.85a	.73b	.20c	.21c	.77b

Note. px/frm-1 = inter-frame pixel change. Dissimilar letter subscripts denote differences at $p < .05$.

3.2.2.2 Individual SDs. The standard deviations of their speeds were not affected by movement condition, $F(4, 147) = 0.48$, $p = .75$, $\eta_p^2 = .013$. Hence, though the degree of temporal alignment differed between conditions, co-actors' individual profiles did not, $BF_{01} = 22.94$.

3.2.2.3 Cross-correlations. As with co-actors' inter-frame correspondence, the *r*-to-z transformed correlations between participants' movement speeds were affected by movement condition, $F(4, 71) = 429.88$, $p < .001$, $\eta_p^2 = .96$ (see Table 13). Synchrony gave rise to more co-actor correspondence than all other conditions (all $p < .01$). Paired asynchrony and B2B baseline did not differ from each other ($p = .20$) but led to greater temporal correspondence than delayed action and total misalignment (all $p < .001$). Delayed action led to least temporal alignment however (compared with total misalignment, $p < .02$).

3.3 Mediation of the alignment–affiliation relationship. Inter-measure correlations are presented in Table 14. As in Chapters 2–3, perceived alignment correlated reliably with participants' affiliation ratings. In conjunction with the fact that it was systematically affected in the same manner as affiliation, we again tested whether perceived synchrony acts as a mediator of the alignment–affiliation relationship.

As in Experiment 2, we tested a mediation model in which the association between movement type and affiliation is at least partly accounted for by perceived alignment. We tested this theoretical model via a regression model, using the SPSS PROCESS macro written by Hayes (2013; Preacher, Rucker, & Hayes, 2007). A bootstrapping analysis with 10,000 estimates was used for the construction of 95% bias-corrected confidence intervals for the indirect effects. Four of the five conditions

Table 13
Inertial Motion Measures [and 95% CIs] as a Function of Movement Condition, Experiment 3

	Synchrony (n = 30)	Paired Asynchrony (n = 30)	Delayed Action (n = 32)	Total Misalignment (n = 29)	Back-to-Back (n = 30)
Individual mean (m/s)	.020 [.019, .022]a	.021 [.020, .023]a	.021 [.020, .022]a	.021 [.020, .023]a	.022 [.021, .024]a
Individual SD (m/s)	.021 [.019, .023]a	.022 [.020, .024]a	.022 [.020, .023]a	.022 [.020, .024]a	.023 [.021, .025]a
Cross-correlation (lag 0 sec)	.60a	.48b	-.41c	-.32d	.51b

Note. Dissimilar letter subscripts denote differences at $p < .05$.

were dummy coded, thereby allowing the fifth (B2B baseline) to act as reference group.

As Figure 5 shows, the perceived alignment of co-actors' movements statistically mediated the effect of movement condition on affiliation (see also Appendix E). Perceived alignment was affected by movement condition, $F(4, 146) = 18.19$, $p < .001$, $R2 = .33$, and in turn predicted affiliation, $b = 0.22$, $p < .001$. Furthermore, in all of the regression analyses, the 95% confidence interval for the mediatory effect did not include zero. Hence, we found evidence that the perceived alignment of co-actors during the movement task mediated affiliation.

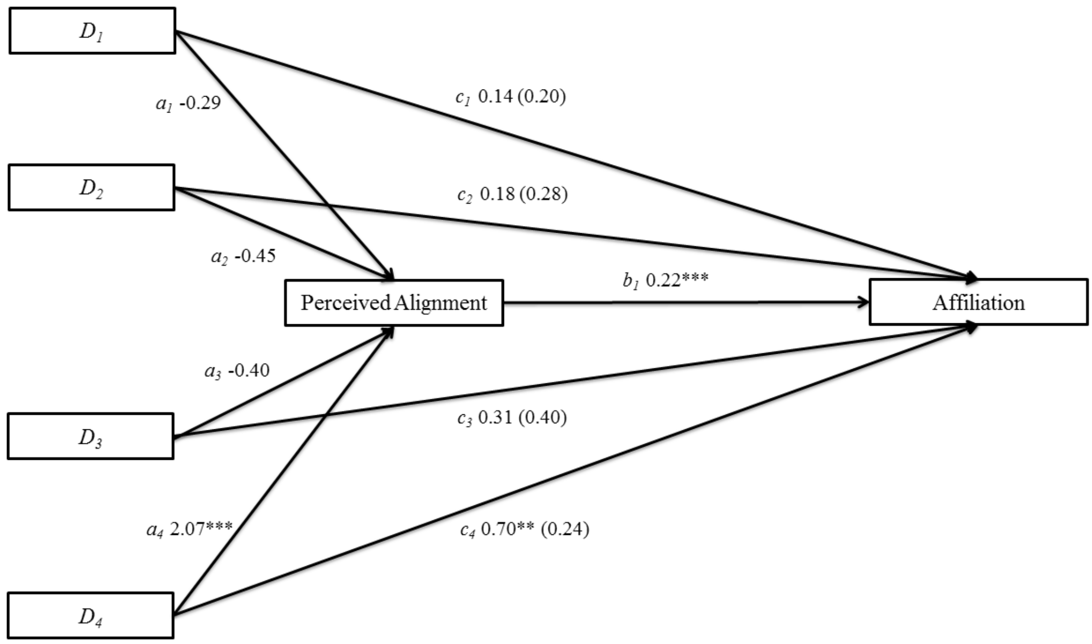

Figure 5. Model depicting the effects of interpersonal movement condition on affiliation, Experiment 3. Groups were categorized according to movement condition: Total Misalignment (D1), Paired Asynchrony (D2), Delayed Action (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to perceived alignment, *b* = perceived alignment to affiliation, *c* = movement condition to affiliation. Direct effect (c') presented in parentheses. $*p < .05$, $**p < .01$, $***p < .001$.

Table 14

Correlations between Dependent Measures, Experiment 3

		1	2	3	4	5	6	7	8	9	10	11	12
1	Affiliation	-											
2	Perceived alignment	.38**	-										
3	Projection: Ratings	.15	.17	-									
4	Projection: RT	.17*	.09	.18*	-								
5	Digital: Co-actor correlation	.10	.40**	.06	.10	-							
6	Digital: Individual mean	-.07	.02	.04	.02	.07	-						
7	Digital: Individual SD	-.04	.08	-.14	-.03	.21*	.86**	-					
8	Digital: Co-actor SD	-.04	-.02	.17*	.06	.21*	-.13	-.22**	-				
9	Inertial: Co-actor correlation	.07	.38**	.11	.07	.87**	.01	.17*	.17*	-			
10	Inertial: Individual mean	-.15	-.08	-.05	-.07	-.01	.09	.14	.18*	.00	-		
11	Inertial: Individual SD	-.13	-.07	-.04	-.04	.01	.04	.13	.21*	.01	.95**	-	
12	Inertial: Co-actor SD	-.15	-.14	.10	-.08	.01	.15	.21*	.13	.01	.37**	.35**	-

Note. "Digital" and "Inertial" refer to the dependent indirect measures of temporality (speed) and topology (no. of pixels to change between frames) respectively. * p <.05, ** p < .01

3.4 Exploratory analysis of synchrony–perceived alignment relationship.

Inter-frame cross-correlation and speed cross-correlation correlated significantly with perceived alignment (see Table 14). Given the significant nature of their relationships with perceived alignment and that each of these objective measures of interpersonal alignment was systematically affected by movement condition, inter-frame cross-correlation and speed cross-correlation were each examined as candidate mediators for the effect of movement condition on perceived alignment. Their mediation effects were tested independently of each other using the same procedure as was used to test the mediation effect of perceived alignment on affiliation (see above): Bootstrapping analysis with 10,000 estimates was used for the construction of 95% bias-corrected confidence intervals for the indirect effects. Four of the five conditions were dummy coded, thereby allowing the fifth (B2B baseline) to act as reference group.

Though inter-frame and speed cross-correlation were both influenced by movement condition (inter-frame: $F(4, 146) = 126.15$, $p < .001$, $R2 = .78$; speed: $F(4, 146) = 884.76$, $p < .001$, $R2 = .96$), neither measure predicted perceived alignment (inter-frame: $b = -0.26$, $p = .58$; speed: $b = -1.26$, $p = .27$; see Appendix F and Appendix G). Furthermore, in all of the regression analyses, the 95% confidence interval for the mediatory effect included zero. Therefore, we found no evidence that either inter-frame cross-correlation or speed cross-correlation mediated perceived alignment.

4. Discussion

The present experiment examined the affiliative effects of temporal and topological *mis*alignment on affiliation. As in Experiments 1–2, affiliation levels evoked by temporo-topological alignment (synchrony) were greater than the affiliative effects of all other conditions. No other comparisons differed. That is, non-concurrent (e.g., delayed action, total misalignment) and concurrent (paired asynchrony) forms of misalignment did not affect affiliation relative to B2B baseline. There was no prioritization of any form of misalignment in terms of its affiliative effects either. Though interpersonal movement that was aligned on all dimensions (synchrony) led to increases in affiliation, interpersonal movement that was misaligned across dimensions (paired asynchrony, total misalignment) did not lead to reductions in affiliation. Nor did misalignment conditions differ from each other in terms of the level of affiliation they evoked. These effects are consistent with a perceived alignment mechanism, for which no effect on affiliation by the misalignment conditions was predicted.

4.1 Concurrent Movement

Similar to Chapters 2 and 3, comparing the affiliative effects of synchrony (temporo-topological alignment) with other interpersonal movements that were variously misaligned enabled further exploration of the affiliative contributions of misalignment in general—across dimensions—rather than merely temporal misalignment (e.g., asynchrony).

Two non-concurrent (i.e., globally temporally misaligned) movement types were included in the present experiment (delayed action, total misalignment). The non-concurrent movement type used in the previous experiments (turn-taking) did not increase affiliation, in spite of the fact that it consisted of temporal and topological alignment (i.e., interpersonal movements were set to the same tempi and consisted of the same movement trajectories). In the present experiment, one non-concurrent interpersonal movement (delayed action) was included in which participants' movements were set to the same tempo as the co-actor's, but these consisted of different movements (i.e., temporal alignment and topological misalignment). A second non-concurrent movement type (total misalignment) was also included consisting of movements which were set to different tempi and involved different movements (i.e., temporal misalignment and topological misalignment). Neither of these conditions increased affiliation levels relative to baseline. Given that, in all cases, these non-concurrent interpersonal movement types failed to increase (e.g., turn-taking) or decrease (e.g., total misalignment) affiliation levels, we conclude that non-concurrent movement conditions are less likely to evoke affiliation change than interpersonal movements that are completed at the same time as the co-actor's. In other words, concurrent movement may be a necessary prerequisite for affiliative change, and part of the reason why synchrony increases affiliation.

A condition that involved concurrent interpersonal movements and that contained temporal and topological misalignment was also included (paired asynchrony). This condition was incorporated in order to determine whether the increases associated with paired action (temporal alignment and topological misalignment) and asynchrony (temporal misalignment and topological alignment) in the previous experiment had occurred merely because the interpersonal movements in each case took place at the same time as the co-actors (i.e., though not temporally (asynchrony) or topologically (paired action) aligned with co-actor's movements). In other words, we wished to test whether the mere act of undertaking movements together, rather than conducting them during the co-actor's rest periods, can increase affiliation relative to baseline. This condition did not evoke affiliation levels which differed from baseline. So, although non-concurrent movements did not affect affiliation, and hence concurrent movement may be a necessary prerequisite for affiliative change, concurrent actions are not sufficient to increase affiliation relative to B2B baseline.

We contend that the affiliative effects of paired action and asynchrony in the previous experiment (Chapter 3) may therefore have arisen due to the presence of alignment on one dimension in each case (paired action: temporal; asynchrony: topological), rather than the fact that these interpersonal movement types consisted of merely concurrent interpersonal movements. It was not clear whether the reason for the lower affiliative scores in these conditions, relative to synchrony, was because alignment was present on only one dimension in each case, or because misalignment, which was present on the other dimension, reduced affiliation. Turning to synchrony, the reason that synchrony evokes positive affiliative effects may be, in part, due to the lack of misalignment it involves. The present experiment sought to test whether the misalignment which was present in each condition may have reduced affiliation. Paired asynchrony, delayed action and total misalignment did not evoke affiliation levels that were different (i.e., less than) B2B baseline. In other words, no misalignment condition (including paired asynchrony) influenced affiliation. The fact that misalignment did not reduce affiliation relative to B2B baseline suggests that misalignment may not have a negative impact, or any effect, on affiliation. In sum, the effects of synchrony are likely to arise because it consists of concurrent movements that are both topologically and temporally aligned.

Previous research has shown that mimicry is likely to evoke many of the same outcomes as synchrony (Van Baaren *et al*., 2009). However, mimicry typically entails the imitation of discrete rather than rhythmic movements (e.g., postures; Chartrand & Van Baaren, 2009). Furthermore, when mimicry is detected by the mimickee it fails to produce the affiliative increases commonly attributed to mimicry (Bailenson, Yee, Patel, & Beall, 2007). Perhaps the analogue for mimicry (turn-taking), and the remaining non-concurrent movements, used across these experiments (Chapters 2-4) were too explicit to engender the affiliation levels which might have otherwise been obtained.

4.2 Perceived Alignment

Perceived alignment was affected by movement condition, correlated with affiliation levels, and statistically mediated the affiliation levels elicited by interpersonal movements. This mediation effect of perceived alignment on affiliation arising from interpersonal movement replicates the findings in the previous chapter.

Misalignment did not affect affiliation levels. Interpersonal movements have both a temporal and a topological component. Interpersonal movements which are aligned on only one dimension must be misaligned on the other. Yet misalignment did not predict the affiliative effects for misaligned interpersonal movements. Non-concurrent movements which were not aligned topologically or temporally were not reported to seem any less aligned, and did not evoke lower levels of affiliation, than concurrent movements which lacked temporal and topological alignment. Only alignment predicted outcome.

Furthermore, there was no relationship between the objective measures of alignment (inter-frame cross correlation, speed cross correlation) and affiliation, in spite of the correlation between these measures and perceived alignment.

4.3 Conclusion

In this experiment, dyads performed arm movements consisting of synchrony (temporally and topologically aligned), paired asynchrony (temporally misaligned and topologically misaligned), delayed action (non-concurrent, temporally aligned and topologically misaligned), or involved total misalignment (non-concurrent, temporally misaligned and topologically misaligned). In order to control for the possible effects of the movements themselves, participants in one condition completed the task while facing away from their co-actor (back-to-back baseline). To determine whether self–other overlap mediates the affiliative outcomes of alignment, participants completed measures that assessed their perceptions of their own and their partner's personality. To investigate whether perceived alignment is responsible for outcome, they then completed items assessing the degree to which they judged themselves to have been aligned with their partner during the interpersonal movement task.

Participants in the synchrony condition reported more alignment than in all other conditions. Affiliation was not affected in the misaligned conditions relative to the B2B baseline. Alignment rather than motor interference or misalignment predicted affiliation levels. Moreover, none of the misalignment conditions affected affiliation. Given that temporo-topological misalignment and non-concurrent movements, had no impact on affiliation levels, concurrent movements would seem to be a necessary, though not sufficient, basis for affiliation arising from interpersonal movements. Alignment, and not misalignment, predicted affiliation. Furthermore, perceived alignment mediated the relationship between movement condition and affiliation. This experiment has therefore provided further evidence that perceived alignment mediates the affiliation levels that are evoked by interpersonal movement.

CHAPTER 5: GENERAL DISCUSSION

This chapter returns to the rationale for the studies reported in this thesis. Key findings are summarised, such as the relationship between alignment and action co-representation (Experiment 1), interpersonal projection (Experiments 2-3) and judgments about alignment (Experiments 2-3). The relative effects of different types of alignment and misalignment are restated, and the implications of these are explored. For example, the importance of alignment and concurrent movement to affiliation is discussed. The novel approaches that this thesis relied upon and their benefits are mentioned, in turn. These included innovations such as the development of a taxonomy that categorised interpersonal movements according to their dimension of alignment. A number of relatively novel measurement and analysis techniques were also used, such as inter-frame differencing techniques in conjunction with inertial displacement measures to quantify alignment (experiments 1-3). Key caveats and limitations of this thesis are highlighted. The chapter concludes the present thesis by summarising the contribution that this research has made to the research area.

Previous research has shown that affiliation is greater for synchrony than asynchrony. With a few notable exceptions, little research has explored the effects of synchrony relative to paired action (Tarr et al., 2015) or a suitable baseline (e.g., Hove and Risen, 2009; Wiltermuth, 2012). To our knowledge no research has compared the affiliative effects of all three movement types against baseline, or investigated the effects of misalignment. Furthermore, the mediational mechanisms underpinning these effects have remained underspecified. These issues affecting the field were investigated throughout this thesis.

One mechanism which could be responsible for the social effects of alignment is self-other overlap (Smith, 2008). During aligned interpersonal movements, participants receive sensory input from themselves and their co-actor. The more similar their own movements are with the co-actors', the more likely it is that the sensory cues arising from their own movements would match the sensory cues evoked by their co-actor's movements. This might result in participants processing sensory input from themselves and their co-actor as being their own. Hence the sensory overlap arising from sensorimotor alignment with the co-actor could lead to bodily or psychological self-other overlap. Since there is as yet no direct evidence for the role of this mechanism in synchrony and mimicry, we tested this idea. In Chapter 2, we investigated the degree to which action co-representation (akin to physical self-other overlap) mediates the affiliative effects of movement, whereas in Chapters 3 and 4 we explored the degree to which interpersonal trait projection (psychological self-other overlap) or meta-judgments about the level of alignment present can account for the affiliative effects of alignment.

1 Coming Together: Summary of the Findings

Chapters 2 and 3 investigated the affiliative effects of temporal and topological *alignment* on affiliation. Dyads completed interpersonal movements that were aligned on one (topological: asynchrony; temporal: paired action) or both (synchrony) dimensions; or completed movements in which they took turns making the same movements at the same tempo (turn-taking), somewhat akin to mimicry. A movement-only baseline condition was also included in which participants made the same movements at the same tempo, while facing away from the co-actor (B2B baseline).

1.1 Action Co-Representation as Mediator

Dyads completed a joint Simon task after their interpersonal movements task (Chapter 2). Given that the joint Simon effect, obtained during the joint Simon task, purportedly indexes action co-representation (Sebanz, Knoblich, & Prinz, 2003; Sebanz, Knoblich, & Prinz, 2005), we sought to test whether the degree of action co-representation that is elicited by interpersonal movements mediates affiliation level. The joint Simon effect was not affected by movement condition, and did not predict affiliation levels.

However the joint Simon task may not index action co-representation. For example, the joint Simon effect as been obtained in experiments were objects such as a rotating pendulum clock, have been used in place of the co-actor (Dolk et al., 2013). If the joint Simon effect may index may be obtained with non human (and non-human-like) objects it may not index action co-representation.

The effects of movement condition on affiliation are also inconsistent with those that would be expected if action co-representation were a mediator. Asynchrony, paired action, and even turn-taking, all consisted of movements which are aligned on at least one dimension (see Table 1). Indeed the joint Simon effect itself is obtained during a go/no-go task characterised by turn-taking with the co-actor (see Sebanz, Knoblich, & Prinz, 2003). Given the presence of alignment, asynchrony, paired action, and turn-taking, should all have increased action co-representation. Yet these conditions did not unanimously evoke affiliation levels any greater than baseline. Indeed, even in the subsequent chapter, turn-taking failed to increase affiliation levels.

1.2 Interpersonal Projection versus Perceived Alignment.

In Chapter 3 we tested whether interpersonal projection or meta-judgments concerning the degree alignment with the co-actor mediate the effect of interpersonal movement on affiliation levels. As mentioned previously interpersonal projection can be thought of as a type of psychological self-other overlap.

Participants completed the same interpersonal movements task as in Chapter 2, but rather than undertaking a joint Simon task together, they completed a battery of questionnaires independently. These assessed interpersonal projection via two identical personality inventories; one assessed respondents' beliefs about their own personality, and the other, their judgements about their co-actor's personality. Cross-correlations of these trait rating scores for self and co-actor (interpersonal projection) were the same across conditions (synchrony, paired action, asynchrony, turn-taking, B2B baseline). Moreover, in the response time measure that assessed the speed with which they could dissociate their own traits from their co-actor's (me/not me task) response latencies were not affected by movement. And so, interpersonal projection did not mediate the affiliative outcomes of interpersonal movement.

In contrast, participants judgments about the degree of alignment with the co-actor was affected by condition. Participants reported the degree to which they perceived themselves as having been aligned in the interpersonal movements task (i.e., in sync, coordinated). Not only was perceived alignment with the co-actor affected by movement condition and predictive of self-reported affiliation levels, but regression analyses indicated that perceived alignment statistically mediated the level of affiliation elicited by movement condition. Conceptual shortcomings of mediation-by-measurement aside (Spencer, Zanna, & Fong, 2005), Chapter 3 indicated that perceived alignment may play a significant intermediary role in bringing about the affiliative outcomes of alignment.

Differences between affiliation levels in each condition shed further light on the alignment-affiliation relationship. As in the Chapter 2, synchrony led to elevated levels of affiliation relative to all other conditions, including paired action, asynchrony, and turn taking. However, unlike Chapter 2, the effects of paired action and asynchrony were greater than those reported for B2B baseline. We speculated that either performing movements at the same time as the co-actor (i.e., concurrently) leads to affiliation increases, or that alignment on only a single dimension may be sufficient to do so. The fact that paired action and asynchrony consisted of alignment on one dimension and misalignment on the other presented a problem: Given that these conditions evoked increased affiliation, either alignment on one dimension in these conditions increased affiliation and misalignment had a lesser negative impact, or misalignment had not affect at all. In other words, were elevated affiliation levels evoked by paired action and asynchrony truly reflective of the independent contributions of temporal and topological alignment to affiliation, or did the presence of misalignment in each case (paired action: topological; asynchrony: temporal) reduce the affiliation levels to some degree?

1.3 Perceived Alignment and Interpersonal Misalignment.

Rather than conducting movements that were aligned on at least one dimension, co-actors in Chapter 4 completed interpersonal movements that were concurrent but misaligned across dimensions (paired asynchrony: temporal and topological misalignment) or were non-concurrent (i.e., globally temporally misaligned) and either aligned only in terms of the internal temporal structure of the movements themselves (delayed action: temporal alignment [same tempi] and topological misalignment) or misaligned across dimensions (total misalignment: temporal and topological misalignment). In all other respects the experiment was the same as Experiment 2. Interpersonal projection and perceived alignment were again included as potential mediators, and affiliation was measured the same as in

Experiments 2 and 3. In order to enable further investigation of the relative effects of alignment and misalignment, a synchrony (temporo-topological alignment) and B2B baseline (participants completed the same movements at the same tempo while facing away from their co-actor) condition were also included.

As with Chapter 3, in spite of the effect of condition on affiliation interpersonal projection (trait projection and self-other trait discrimination RTs) was not affected by condition. Hence, interpersonal projection did not mediate of the affiliative effects of condition. However, again, perceived alignment was influenced by movement condition, and statistically mediated the degree of affiliation which was elicited by interpersonal movement. These results replicated the alignment-meta-judgment-affiliation relationship found in the previous chapter.

This experiment sought to determine the effect of misalignment on affiliation, and so a number of misaligned movement conditions were included (e.g., paired action; total misalignment). However, affiliation levels were only affected by synchrony relative to B2B baseline. No other interpersonal movement type influenced affiliation. In other words, neither of the conditions that were characterised solely by misalignment whether conducted concurrently (paired asynchrony) or non-concurrently (total misalignment), affected affiliation relative to B2B baseline. Thus, even when misalignment was present on both dimensions it failed to reduce affiliation levels. In light of this we concluded that the misalignment which was present on one dimension in paired action (topological misalignment) and asynchrony (temporal misalignment) had not counteracted the positive affiliative effects of alignment present on the other dimension (paired action: temporal alignment; asynchrony: topological alignment).

An additional objective of this chapter was to explore the relative effects of non-concurrent interpersonal movements. In Chapters 2 and 3, turn-taking had failed to increase affiliation. This, in spite of the fact that although turn-taking consist of globally misaligned (i.e., non-concurrent) movements, co-actors in this condition performed the same movements at the same tempo. For concurrently conducted movements temporo-topological alignment (synchrony) has been associated with affiliative increases yet in these experiments when the same movements set to the same tempo are globally offset these affiliative effects disappear. Clearly concurrency was a necessary prerequisite for these effects. In Chapter 4, neither delayed action nor total misalignment affected affiliation relative to B2B baseline. Given that delayed action involved co-actors performing different movements at the same tempo during each-other's rest periods, this condition was a non-concurrent equivalent of paired action. Though paired action increased affiliation relative to baseline, delayed action did not, just as turn-taking in Chapters 2 and 3 did not improve affiliation either. Hence, whether alignment is present on one (paired action: temporal) or both (synchrony: temporo-topological) dimensions, concurrent movement is necessary for affiliative change. Yet, concurrent movement was not a *sufficient* basis for affiliative change. Paired asynchrony, which was comprised of concurrent movements that were temporally and topologically misaligned, evoked no affiliative increases relative to B2B baseline. Alignment on at least one dimension (e.g., temporal: paired action; topological: asynchrony; temporo-topological: synchrony) is therefore essential.

2 Methodological Approaches

This thesis sought to investigate the mechanisms underpinning the affiliative outcomes of interpersonal alignment. To help with this task, novel methodological approaches were combined with those that are more commonly used in the field.

2.1 Objective Measures of Movement - Kinematic Analysis.

Moving in synchrony with another person promotes more affiliation (e.g., Hove & Risen, 2009). This has mostly been tested via manipulation of temporal alignment during interpersonal movement tasks, (e.g., Wiltermuth & Heath, 2009)). Although participants in these tasks were asked to perform synchronous and asynchronous movements, the extent to which participants were actually synchronized has rarely been reported. Furthermore, aspects of motor function (e.g., topological SD) that are likely to be affected by the task itself (e.g., Kilner et al., 2003), are usually not examined. Across experiments, two objective measures of synchronization and other temporal and topological components of movement were included.

2.1.1 Inertial motion data. Velocity profiles were recorded using two synchronized inertial displacement monitors (Opals; APDM, Portland, OR). The use of inertial monitors allowed us to assess the temporal similarity of co-actors' movements via a cross-correlation (lag: 0 seconds) of the co-actors' speed profiles. These also enabled novel examination of the relationships between specific aspects of each participant's movement profile (e.g., their speed SD) and affiliation (see Table 14).

2.1.2 Digital video data. The inertial measurement sensors that were used do not enable measurement of topological features of movement. We therefore additionally recorded participants' movements with a digital camera for the duration of the movement task. This allowed us to measure the amount of change occurring in the movement task, by measuring the amount of change which occurred over successive images. For every recording, pixel-by-pixel inter-frame differences were calculated for co-actors independently (Ramsayer and Tschacter, 2008). These pixel change measures thus enabled us to quantify the similarity of the movements in the temporal and topological domains. As with speed, this measure allowed us to assess the temporal similarity of co-actors' movements via a cross-correlation (lag: 0 seconds) of the co-actors' speed profiles. Each participant's discrete distributions were also assessed. Just as with temporal correspondence, this allowed us to explore the relationships between specific features of co-actors' movements and affiliation (see Table 14).

2.2 Mediation Analysis

Aligned interpersonal movements have been associated with greater affiliation (Tarr, Launay, Cohen, & Dunbar, 2015). These findings are surprising given that the movement types themselves may differ drastically. One possible explanation for these effects could be a common factor that mediates the effect of movement condition on affiliation. Mediational analysis with bootstrapping is a non-parametric tool which we used to elucidate these factors across interpersonal movement types (see Hayes & Preacher, 2014). Using this statistical technique we were able to elucidate on the mediatory relationship between high order interaction meta-judgments about task alignment (perceived alignment) and the degree of affiliation that interpersonal movements evoke (see Chapter 3 and 4). Although mediational variables require direct experimental manipulation in order to confirm their status as mediators, this technique greatly increased the specificity with which the alignment-affiliation relationship could be examined.

2.3 Bayesian Statistics

All statistical analyses reported in this thesis use classical frequentist approaches. As frequentist null-hypothesis testing does not provide us with evidence for the absence of an effect, additional Bayesian analyses were conducted (Rouder, Speckman, Sun, Morey, & Iverson, 2009; Jarosz & Wiley, 2014) for comparisons of interest when no effect (p > 0.05) was obtained. Specifically we calculated JSZ Bayes Factors with default prior scales (r = 0.707) (Rouder, Speckman, Sun, Morey, & Iverson, 2009). Bayes Factors ($BF_{01,}$ BF_{10}) compare the probability that the data would be observed if the null hypothesis were true (H0 - there is no difference between the conditions) with the probability that it would be observed if the alternative hypothesis were true (H1- there is a difference between the conditions; Jarosz & Wiley, 2014; Morey, Romeijn, & Rouder, 2016):

$$BF_{01} = \frac{p(data|H0)}{p(data|H1)}$$

The greater the Bayes Factor (BF_{01}) the greater the evidence for the null hypothesis. For example, a BF_{01} of 8 indicates that the data is 8 times more likely to reflect the null than the alternative hypothesis, while a BF_{01} of 2 suggests it is only twice as likely to reflect the null (Jarosz & Wiley, 2014; Braun, Sokoliuk, & Hanslmayr, 2017). In addition to calculating the odds, cut-off values for interpreting the Bayes Factor have been proposed (Jeffreys, 1961). A BF_{01} of more than 3 has traditionally represented evidence for the null whereas a BF_{01} of less than 0.3 is seen as evidence for the alternative hypothesis. A variety of other more stringent cut-offs have since been proposed with BF_{01} greater than 6 (Schönbrodt, Wagenmakers, Zehetleitner, & Perugini, 2017) and 10 (Etz & Vandekerckhove, 2016) purportedly providing reliable cut-offs for evidence favoring the null. However, unlike frequentist statistical analysis, Bayesian analysis does not rely on cut-offs. Bayesian approaches describe the probability of the data given the null and the data given the alternative hypothesis, not whether the data itself (e.g., differences between two data sets) was observed by chance (i.e., likely to be false). Hence, unlike frequentist null hypothesis testing, Bayesian inferences are explicitly and solely probabilistic (Cumming, 2014; Jarosz & Wiley, 2014; Morey, Romeijn, & Rouder, 2016).

2.4 Manipulating Alignment in the Present Thesis

Unlike past research, in this thesis interpersonal movements were manipulated in terms of both their temporal and topological alignment, rather than on only one dimension (see Chapter 1). That is, movements were the same (topologically aligned) or different (topologically misaligned), set to the same tempo (temporally aligned) or different tempi (temporally misaligned), conducted while the co-actor made their movements (i.e., concurrently) or during the co-actor's rest period (non-concurrent). By manipulating movements in each dimension we revealed that alignment on one dimension (temporal: paired action) leads to similar outcomes as alignment on the other dimension (topological: asynchrony; Chapter 3). In conjunction with our findings in Chapter 4 that misalignment has no effect on outcome, this taxonomic approach led us to infer that alignment itself has positive affiliative effects.

3 Caveats and Limitations

The elevated levels of affiliation for asynchrony and paired action (relative to B2B baseline) found in Chapter 3, were not found in Chapter 2. We took the affiliation findings in Chapter 3 to be the more valid since participants in Chapter 2 conducted a joint Simon task together before affiliation was assessed. Since this Simon task consisted of physical interaction (i.e., turn-taking keypress responses while seated side by side) we speculated that it may have weakened the affiliative effects arising from alignment. Future research should seek to replicate the positive effects of asynchrony and paired action found in the Chapter 3.

Our use of a baseline in which participants completed the same movement while facing away from their co-actor (B2B baseline) is unusual. The use of baselines in this type of research are rare. Where present they have often provided actors with information about the alignment status of the confederate or co-actor. Hove and Risen (2009), for example, had participants performing movements while the confederate remained with her hands on her lap in full view of the participant. As a result participants were provided with visual cues informing them that the confederate in the control condition was not in fact performing the same task that they were. Although participants' perceptions of confederates during control conditions such as these are unclear, a non-moving confederate might be interpreted as equivalent to partial alignment and partial misalignment. If true, it's little wonder that Hove and Risen failed to detect affiliative differences between asynchrony (topological alignment, temporal misalignment) and baseline.

The baseline we used sought to control for the possible affiliative effects of the movements themselves. Unlike the research cited above it was also information free. Yet we did not explore how participants perceived co-actors whom they could not see. Since our conclusions concerning the affiliative effects of alignment were based in large part on comparisons between movement conditions and this B2B baseline, participant's perceptions of their co-actors in this baseline should be tested.

Lastly, although the turn-taking condition was intended to act as an analogue of mimicry, turn-taking is distinct from mimicry. In the present thesis, alignment was manipulated by entrainment to shared or unshared external cues stimuli. That is, co-actors responded to stimuli that were matched or mismatched temporally and topologically. As a result, their movements were aligned or misaligned on these dimensions. In the synchrony condition (temporo-topological alignment), for example, co-actors were presented with matched stimuli at the same time and tempo. Consequently, co-actors’ movements were themselves temporally and topologically aligned (i.e., synchronous). In the turn-taking condition—our analogue for mimicry—co-actors were presented with the same stimuli which were presented at the same tempi to each co-actor. However, unlike synchrony, these stimuli were presented during the co-actor's rest periods. Hence, in the turn-taking condition, although co-actors' made the same movements at the same tempi, they did so during each-others' rest periods. In contrast, in mimicry research, experimental manipulations of mimicry usually involve the covert replication of a participant's movements by a confederate (see Chapter 1). Moreover, a variety of different movements are usually mimicked by the confederate across a given mimicry block. The fact that our analogue for mimicry, turn-taking, did not evoke affiliative increases, where mimicry purportedly increases affiliation (e.g., van Baaren et al., 2004), might therefore arise as a result of the differences between our turn-taking condition and mimicry. For example, Bailenson et al. (2007) showed that the affiliative effects of mimicry are lost if mimicry is detected. With this in mind, the movement conditions used throughout this thesis, including the turn-taking condition, were overt–participants faced each-other while making deliberate gross upper body movements. Unlike mimicry therefore, emphasis was placed on the importance of the movements themselves since co-actors were explicitly required to undertake an interpersonal movements task. Perhaps these differences may explain the fact that our analogue of mimicry, turn taking, failed to increase affiliation, where affiliation increases have been reliably detected following mimicry (Van Baaren et al., 2009).

4 Final Conclusions

This thesis sought to determine which mechanisms are responsible for the affiliative effects of alignment. In doing so it uncovered early support for the role of interaction meta-judgments. Movements were classified according to a taxonomy which defined interpersonal movements in terms of their temporal and topological alignment. Irrespective of dimension, alignment increased affiliation. Misalignment had no effect. The effects of concurrent and non-concurrent movements were also compared, and our results indicated that concurrency may be a necessary prerequisite for affiliative change.

Many questions remain open. Perhaps the most pertinent of these has been central to the thesis throughout. Why is alignment so valued?

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Appendix A

Letter order for each stimulus sequence.

Sequence 1

ACE, BDF, CEG, DFA, EGB, FAC, GBD, ACF, BDG, CEA, DFB, EGC, FAD, GBE, ACG, BDA, CEB, DFC, EGD, FAE, GBF, ACA, BDB, CEC, DFD, EGE, FAF, GBG.

Sequence 2

ADF, BEG, CFA, DGB, EAC, FBD, GCE, ADG, BEA, CFB, DGC, EAD, FBE, GCF, ADA, BEB, CFC, DGD, EAE, FBF, GCG, ADB, BEC, CFD, DGE, EAF, FBG, GCA.

Appendix B

Multi-Categorical Mediator: Perceived Alignment, Experiment 2

Table B

Model Coefficients for Multi-Categorical Mediator (perceived alignment), Experiment 2

	Outcome: Perceived alignment		Affiliation		Affiliation via Perceived alignment			
		Coefficient (*SE*)		Coefficient (*SE*)		Effect (*SE*)	LLCI	ULCI
Perceived alignment			*b1*	0.13** (0.03)				
D1	*a1*	1.11** (0.31)	*c1*	0.18 (0.15)	*ab1*	0.15 (0.06)	0.06	0.30
D2	*a2*	0.78* (0.312)	*c2*	0.38* (0.15)	*ab2*	0.10 (0.05)	0.02	0.24
D3	*a3*	0.75* (0.31)	*c3*	0.36* (0.15)	*ab3*	0.10 (0.05)	0.02	0.23
D4	*a4*	2.43** (0.31)	*c4*	1.14** (0.15)	*ab4*	0.33 (0.09)	0.17	0.51

Note. PROCESS macro was used to assess mediation. Confidence intervals were calculated using 10,000 iterations, resulting in a 95% interval estimate. Groups were categorized according to movement condition: Turn-Taking (D1), Paired Action (D2), Asynchrony (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to perceived alignment, *b* = perceived alignment to affiliation, *c* = movement condition to affiliation. LLCI = Lower level confidence interval, ULCI = Upper level confidence interval. *$p < .05$, **$p < .01$

Appendix C

Multi-Categorical Mediator: Inter-Frame Cross-Correlation, Experiment 2

Table C

Model Coefficients for Multi-Categorical Mediator (inter-frame cross-correlation), Experiment 2

	Outcome: Inter-frame cross-correlation		Affiliation		Affiliation via Inter-frame cross-correlation			
		Coefficient (*SE*)		Coefficient (*SE*)		Effect (*SE*)	LLCI	ULCI
Inter-frame cross-correlation			*b1*	-0.06				
				(0.19)				
D1	*a1*	-0.95**	*c1*	0.18	*ab1*	0.06	-0.29	0.39
		(0.06)		(0.15)		(0.17)		
D2	*a2*	-0.08	*c2*	0.38*	*ab2*	0.00	-0.02	0.06
		(0.06)		(0.15)		(0.02)		
D3	*a3*	-0.04	*c3*	0.36*	*ab3*	0.00	-0.01	0.05
		(0.06)		(0.15)		(0.01)		
D4	*a4*	0.20**	*c4*	1.14**	*ab4*	-0.01	-0.09	0.06
		(0.06)		(0.15)		(0.04)		

Note. PROCESS macro was used to assess mediation. Confidence intervals were calculated using 10,000 iterations, resulting in a 95% interval estimate. Groups were categorized according to movement condition: Turn-Taking (D1), Paired Action (D2), Asynchrony (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to inter-frame cross-correlation, *b* = inter-frame cross-correlation to affiliation, *c* = movement condition to affiliation. LLCI = Lower level confidence interval, ULCI = Upper level confidence interval. *p < .05, **p < .01

Appendix D

Multi-Categorical Mediator: Speed Cross-Correlation, Experiment 2

Table D

Model Coefficients for Multi-Categorical Mediator (speed cross-correlation), Experiment 2

	Outcome: Speed cross-correlation		Affiliation		Affiliation via Speed cross-correlation			
		Coefficient (*SE*)		Coefficient (*SE*)		Effect (*SE*)	LLCI	ULCI
Speed cross-correlation			*b1*	-0.33 (0.31)				
D1	*a1*	-0.95** (0.03)	*c1*	0.18 (0.15)	*ab1*	0.31 (0.29)	-0.34	0.78
D2	*a2*	-0.00 (0.03)	*c2*	0.38 (0.15)*	*ab2*	0.00 (0.01)	-0.03	0.03
D3	*a3*	-0.08* (0.03)	*c3*	0.36* (0.15)	*ab3*	0.02 (0.03)	-0.01	0.11
D4	*a4*	0.12** (0.03)	*c4*	1.14** (0.15)	*ab4*	-0.04 (0.04)	-0.12	0.02

Note. PROCESS macro was used to assess mediation. Confidence intervals were calculated using 10,000 iterations, resulting in a 95% interval estimate. Groups were categorized according to movement condition: Turn-Taking (D1), Paired Action (D2), Asynchrony (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to speed cross-correlation, *b* = speed cross-correlation to affiliation, *c* = movement condition to affiliation. LLCI = Lower level confidence interval, ULCI = Upper level confidence interval. *$p < .05$, **$p < .01$

Appendix E

Multi-Categorical Mediator: Perceived Alignment, Experiment 3

Table E

Model Coefficients for Multi-Categorical Mediator (Perceived Alignment), Experiment 3

	Outcome: Perceived Alignment		Affiliation		Affiliation via Perceived Synchrony			
		Coefficient (*SE*)		Coefficient (*SE*)		Effect (*SE*)	LLCI	ULCI
Perceived Alignment			*b1*	0.22*** (0.05)				
D1	*a1*	-0.29 (0.36)	*c1*	0.14 (0.23)	*ab1*	-0.06 (0.09)	-0.26	0.10
D2	*a2*	-0.45 (0.35)	*c2*	0.18 (0.23)	*ab2*	-0.10 (0.08)	-0.29	0.05
D3	*a3*	-0.40 (0.35)	*c3*	0.31 (0.23)	*ab3*	-0.09 (0.08)	-0.27	0.06
D4	*a4*	2.07*** (0.35)	*c4*	0.70** (0.23)	*ab4*	0.46 (0.12)	0.24	0.72

Note. PROCESS macro was used to assess mediation. Confidence intervals were calculated using 10,000 iterations, resulting in a 95% interval estimate. Groups were categorized according to movement condition: Total-Misalignment (D1), Paired Asynchrony (D2), Delayed Action (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to perceived alignment, *b* = perceived alignment to affiliation, *c* = movement condition to affiliation. LLCI = Lower level confidence interval, ULCI = Upper level confidence interval. **p* < .05, ***p* < .01, ****p* < .001.

Appendix F

Multi-Categorical Mediator: Inter-Frame Cross-Correlation, Experiment 3

Table F

Model Coefficients for Multi-Categorical Mediator (Inter-Frame Cross-Correlation), Experiment 3

	Outcome:							
	Inter-Frame Cross-Correlation		Perceived Alignment		Perceived Alignment via Inter-Frame Cross-Correlation			
		Coefficient (*SE*)		Coefficient (*SE*)		Effect (*SE*)	LLCI	ULCI
Inter-Frame Cross-Correlation			*b1*	-0.26 (0.47)				
D1	*a1*	-0.83*** (0.06)	*c1*	-0.29 (0.36)	*ab1*	0.22 (0.38)	-0.53	0.97
D2	*a2*	-0.11 (0.06)	*c2*	-0.45 (0.35)	*ab2*	0.03 (0.06)	-0.05	0.21
D3	*a3*	-0.83*** (0.06)	*c3*	-0.40 (0.35)	*ab3*	0.22 (0.38)	-0.53	0.96
D4	*a4*	0.25*** (0.06)	*c4*	2.07 (0.35)	*ab4*	-0.06 (0.12)	-0.32	0.15

Note. PROCESS macro was used to assess mediation. Confidence intervals were calculated using 10,000 iterations, resulting in a 95% interval estimate. Groups were categorized according to movement condition: Total-Misalignment (D1), Paired Asynchrony (D2), Delayed Action (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to inter-frame cross-correlation, *b* = Inter-frame cross-correlation to perceived alignment, *c* = movement condition to perceived alignment. LLCI = Lower level confidence interval, ULCI = Upper level confidence interval. **p* < .05, ***p* < .01, ****p* < .001.

Appendix G

Multi-Categorical Mediator: Speed Cross-Correlation, Experiment 3

Table G

Model Coefficients for Multi-Categorical Mediator (Speed Cross-Correlation), Experiment 3

	Outcome:							
	Speed Cross-Correlation		Perceived Alignment		Perceived Alignment via Inter-Frame Cross-Correlation			
		Coefficient (*SE*)		Coefficient (*SE*)		Effect (*SE*)	LLCI	ULCI
Speed Cross-Correlation			*b1*	-1.26 (1.14)				
D1	*a1*	-0.90*** (0.03)	*c1*	-0.29 (0.36)	*ab1*	1.13 (0.91)	-0.69	2.87
D2	*a2*	-0.05 (0.03)	*c2*	-0.45 (0.35)	*ab2*	0.06 (0.06)	-0.02	0.25
D3	*a3*	-1.00*** (0.03)	*c3*	-0.40 (0.35)	*ab3*	1.25 (1.01)	-0.78	3.19
D4	*a4*	0.12*** (0.03)	*c4*	2.07*** (0.35)	*ab4*	-0.16 (0.14)	-0.49	0.07

Note. PROCESS macro was used to assess mediation. Confidence intervals were calculated using 10,000 iterations, resulting in a 95% interval estimate. Groups were categorized according to movement condition: Total-Misalignment (D1), Paired Asynchrony (D2), Delayed Action (D3), Synchrony (D4). Back-to-Back acted as the reference variable. Model pathways: *a* = movement condition to speed cross-correlation, *b* = speed cross-correlation to perceived alignment, *c* = movement condition to perceived alignment. LLCI = Lower level confidence interval, ULCI = Upper level confidence interval. **p* < .05, ***p* < .01, ****p* < .001.